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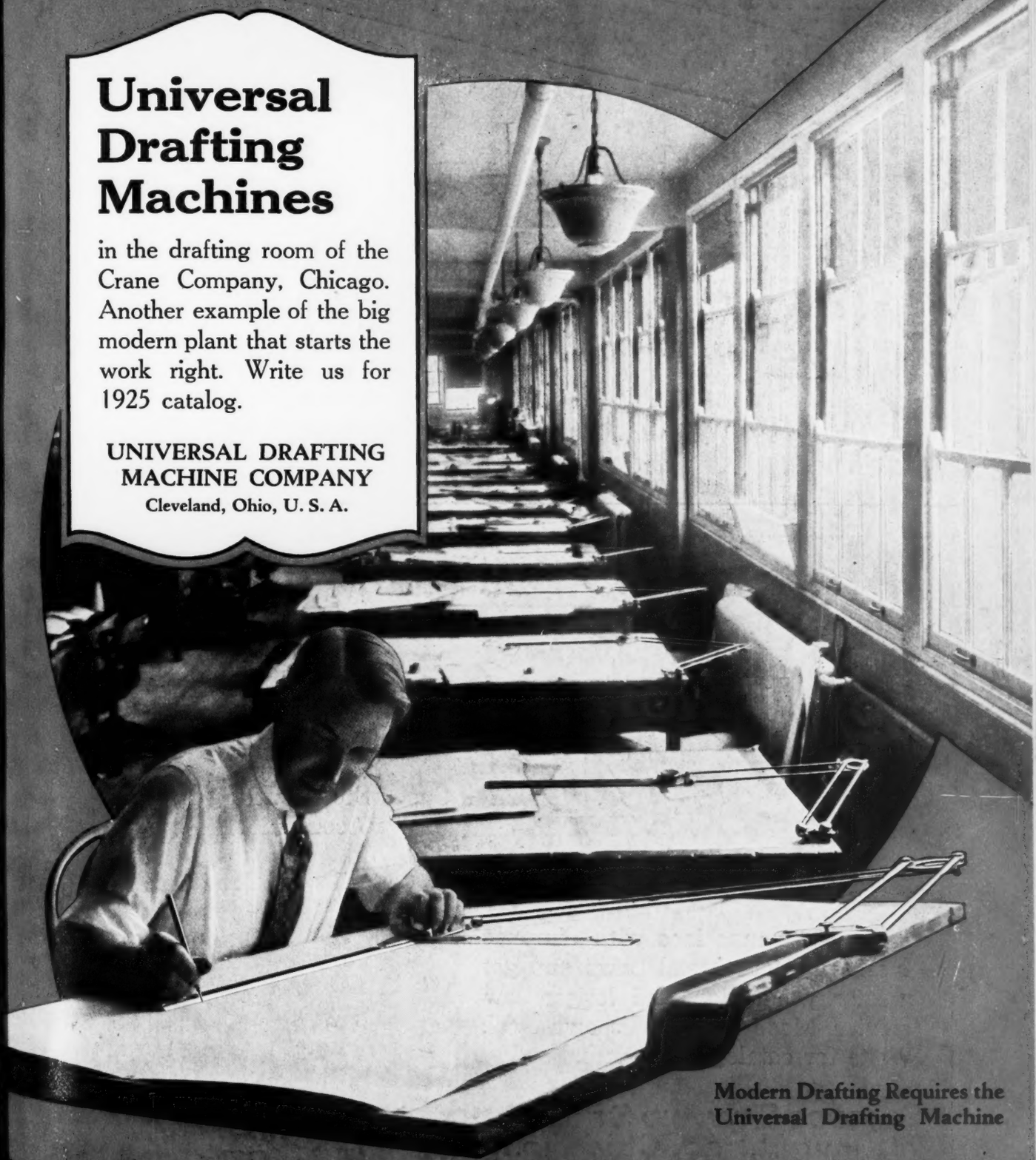

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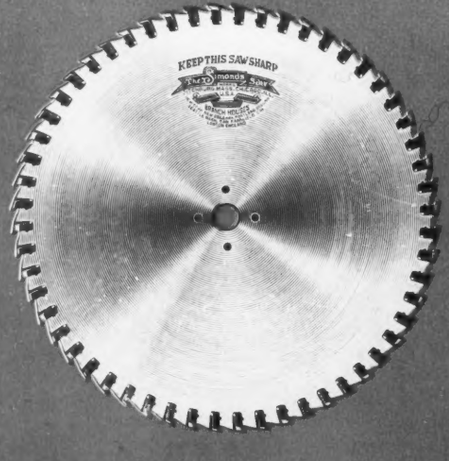

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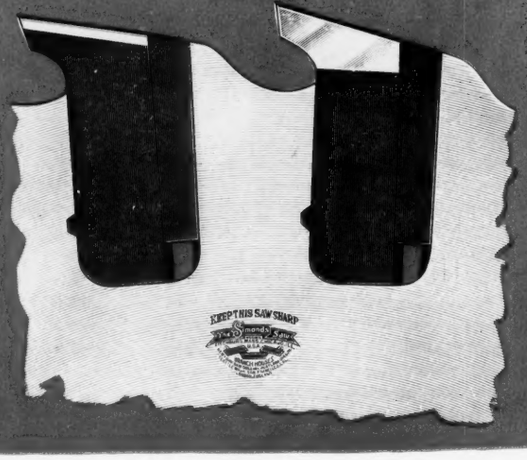

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Generating Precision Tools

Fundamental or Natural Methods of Obtaining Precision in Toolmaking, Gage-making, etc., by the Application of the Generating Principle

By WILLIAM E. HOKE

THE precise generation of fundamental forms is of prime importance in mechanical engineering. These forms include straightedges, parallel straightedges, plane surfaces, parallel plane surfaces, angles, cubes, cylinders, spheres, cones, wedges, and screws. There are methods of generating all these forms in much the same way as we generate straightedges and surface plates. The basic principle on which these methods are established is that any method of producing precision in fundamental forms must necessarily carry within itself the elements of precision which, when followed, will inevitably lead to a perfect result. In other words, there are factors present that enable the worker to start with practically nothing and arrive at a precise result solely by the aid of the principles and methods employed.

The striking thing in connection with these fundamental forms is the ease with which they can be produced if the work is done properly. In the past, precision methods have been complicated, because they have relied upon accurate measurements to obtain results that can be made to produce themselves by natural methods. A 60-degree triangle is a case in point. The most precise triangle heretofore made has been made by producing three links, each of which has a hole at each end. These links must be of equal size in every dimension, the spacing of the holes must be equidistant, and the sides of the links parallel to the center line between the holes. This method of making an equilateral triangle is shown in Fig. 1 The links are fitted over the studs, and in this way equidistant spacing of the studs is achieved for attaching them to the baseplate.

Every mechanic will appreciate the impossibility of arriving at extreme accuracy with this device. The accuracy is limited by the precision with which measurements can be made and applied, and the results can never be better than the measurements; in fact, it is impossible to measure the various elements with high precision by the use of any known instrument. This is due to the different factors that enter into the problem. The three studs, for example, must be of exactly the same diameter, perfectly cylindrical, attached perpendicular to the face of the baseplates, and with equidistant spacing. Each link must be provided with two holes, accurately round, fitting the studs perfectly, and the sides of the links must be perfectly parallel to the line joining the centers of the holes. The slightest variation in any particular defeats the effort to obtain precision. On the other hand, if these conditions are achieved and the links accurately fitted upon the studs, there is produced an internal triangle of 60-degree angles more or less precise. In order to make this accuracy available for mechanical purposes, the triangle is employed as a pattern for making a steel triangle which accurately fits inside the one thus formed by the three links. (See shaded area of diagram Fig. 1). This product can then be employed for mechanical purposes.

The process of making an accurate triangle as previously described is difficult and takes a great deal of time. Almost all of the labor and delay could be avoided by the use of a natural method. In applying this method, simply take two triangular pieces of hardened steel, place them side by side in a fixed position and lap the three sides upon a surface lap. After this step, one of the pieces is turned 60 degrees, fitted against the other piece as before, and the two are again lapped. The turning and lapping operations are continued until the forms match each other in all three positions. When this has been brought about, the pieces are inevitably precise 60-degree triangles, because any two triangles which match each other in every position cannot be anything else.

It is a simple matter for any one to convince himself of the ease with which this may be accomplished. To demonstrate the principle, cut two pieces of strawboard into a form approximating a 60-degree triangle. Hold the two pieces firmly side by side (as represented by diagram *A*, Fig. 4) and rub, successively, all three sides of this double formation on a flat sheet of sandpaper. Then turn one of the pieces 60 degrees (see diagram *B*) and continue to rub and turn (as at *C*) until they fit each

Precision in mechanics is daily becoming more important. The increasing use of machinery has resulted in a more urgent demand for precision operations, and the use of interchangeable parts also emphasizes the need for precise methods of production. There are many methods of obtaining precision. A few of these are in daily use, and many more could be applied to advantage. The importance of these methods makes it desirable that they should be presented in simple practical form. Some methods of especial worth have apparently been overlooked heretofore, and as they have definite value to the toolmaker and others engaged in precision work, the important points and principles involved are presented here to enable the mechanic to simplify many of the problems that arise in connection with precise operations.

other interchangeably. The result is the production of two equilateral triangles of quite high precision. This method is based upon the fundamental law set forth by Euclid that things that are equal to something else are equal to each other. The sum of the angles of any triangle is 180 degrees; one third of this sum is 60 degrees. It is clear, therefore, that if the three angles of each piece are equal to each other, and their sum is 180 degrees, each angle must be one third of 180 degrees, or 60 degrees.

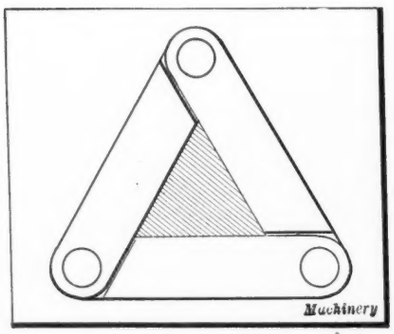


Fig. 1. Three-link Method of producing a 60-degree Triangle

This simple experiment illustrates the ease and accuracy with which precise forms can be generated if we but follow natural methods. The same principle can be applied to the production of polygons with any number of sides, reaching the infinite number that results in precision circles or disks. By following these methods, the shop worker can generate precision without the aid of measuring devices.

Symmetrical Distribution of Errors

Through the application of the principles here set forth the mechanic can make angle-blocks of the highest precision, with means and materials everywhere available. The process is not only useful, but will be found extremely interesting. A few experiments with the strawboard, as previously indicated, will convince the most skeptical as to the value and simplicity of the method. The experimenter will be astonished to see how quickly results are achieved. The mystery that has surrounded the production of angles by the old methods has prevented the average worker from ever attempting such complicated operations. The new method removes this mystery, and the mechanic finds himself possessed of everything required to do a perfect job.

This result has been achieved by "splitting the errors." When one of the triangles is turned 60 degrees with reference to its mate, the failure to match leaves one of the pieces projecting beyond the other. The discrepancy is doubled because it exists in both pieces. The successive fittings, in different positions, cause this projecting tendency to grow progressively smaller. The sandpaper simply removes the "high spots," and as we proceed in transposing and lapping, the result is a continual division of the errors until they disappear, producing two perfect triangles. This is the fundamental principle of all the methods now under discussion—a principle known today as the "symmetrical distribution of errors."

It will be noted that in achieving these results it is the application of a principle that does the work, and not the use of a machine. No machine can be adjusted to produce results measured within a millionth of an inch, but in the application of these methods and principles, the work itself furnishes its own gage of accuracy. We all know that shop practices follow custom. We are apt to do things the way they have been done in the past. There is no denying that simpler methods are the easiest and best and that they are well worth the attention of the worker who is engaged in operations that call for the generation of high precision. There is a broad field for applying these principles, covering a large part of shop practice in the production of precision straightedges, precision angles, built-up precision gages, articles having plane, parallel opposite faces, and precision gears; and in the making of steel balls, cones, plug gages, wrist-pins, and many other articles in which there is need for precision of the highest type.

The basic principle of dividing the errors is one of the oldest in mechanics, as well as one used in daily practice. One of the commonest applications of it is that long used by carpenters in determining the center of a board. Instead of measuring the entire width of the board with a pocket rule, and dividing this total by two, greater accuracy is obtained by "splitting the difference." With a pocket rule, or even a stick, the carpenter measures from one side to a point somewhere near the center. At this point he makes a pencil mark. From the other side he measures the same distance toward the center, and makes a second mark. He then knows that the center lies half way between the two marks thus established, regardless of whether the measurements have overlapped or fallen short of one another. By the application of this same principle, we can achieve high precision in mechanical operations, the chief difference being that of degree. The carpenter finds one division close enough for his purposes. If you want to go further, and obtain higher accuracy, simply continue the process of splitting the error until it reaches the vanishing point. This is readily illustrated by the following process of centering a gear blank.

In gear cutting with a formed cutter, it is essential that the blank be centered with precision. As the first step in this operation, a slight gash is made in the edge of the blank, at the top. The blank is then revolved 180 degrees, bringing the gash to the bottom. The cutter is now lowered so that it will cut upward from beneath, and the gash is made a trifle deeper. If the two gashes coincide the work is truly centered, but invariably it will be found that the second gash is a little to the right or left of the first. The operator now adjusts for removal of one half of the error, as indicated by his first approximation. While the cutter is still at the bottom, he cuts a trifle deeper until all marks of the first gash are obliterated. The cutter is now raised to the original position at the top, the gear blank is turned 180 degrees, and another gash is made. If this gash coincides with the previous one, the work has been accurately

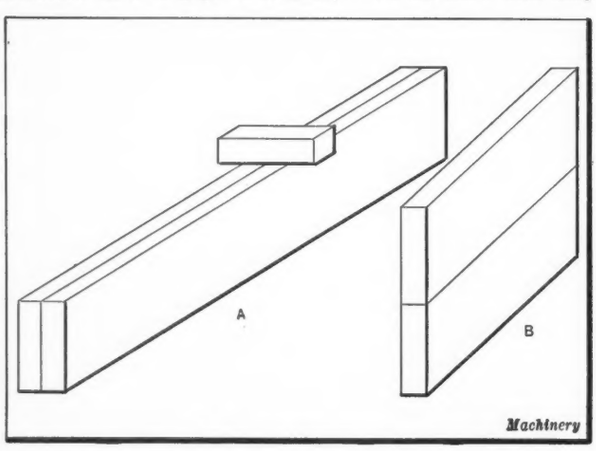


Fig. 2. Simplified Method of making Precision Straightedges

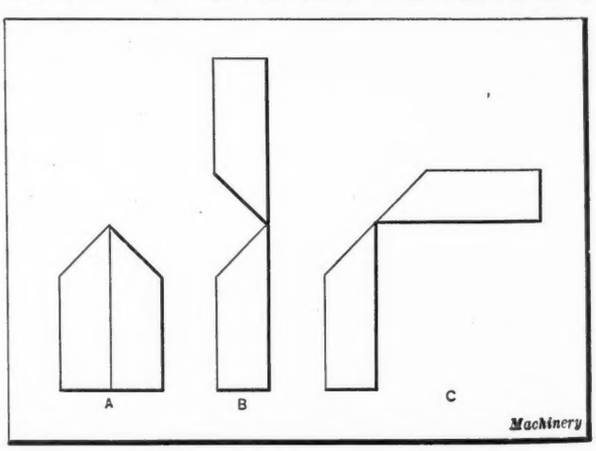


Fig. 3. Method of fitting Knife Straightedges

centered. If not, this method of dividing the error is continued.

This method of centering a gear blank is one of the best known applications of the principle now technically described as "diametrical transposition and the symmetrical distribution of errors." The manufacture of the high precision built-up gages at the United States Bureau of Standards affords a notable example of the employment of this principle. These gages have plane parallel opposite faces, and are so flat that they stick together with great tensile strength. They are accurate to the millionth of an inch and their production is based upon minute refinement of the division of errors.

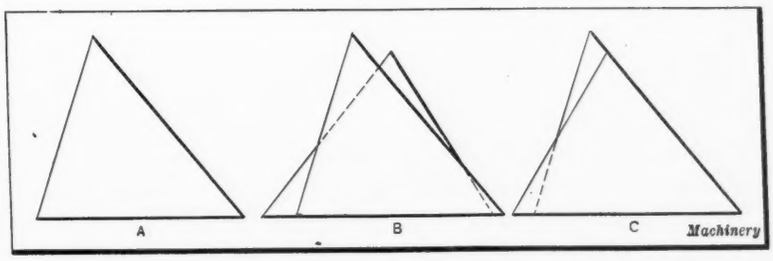


Fig. 4. Diagrams illustrating Natural Method of generating Precision Triangles

Simplified Method of Making Precision Straightedges

It is fundamental that any operation that is highly precise must contain within itself the elements of precision. As a practical illustration, consider the generation of a straight line, as in the case of the straightedge. The usual method of generating straightedges involves fitting three edges together interchangeably. This method is based upon the fact that any three edges that will fit interchangeably are necessarily straight. There is a new method, however, which simplifies the work by reducing the number of straightedges to two. The results are practically perfect.

This new method is based on the principle that any two edges that will fit each other side by side and face to face are inevitably straight. The application of the method can be demonstrated in a simple manner by starting with a surface infinitely thin, such as a sheet of paper, folded and lying flat. Cut through the two thicknesses of paper with a knife blade. By this stroke of the blade you create two new edges. The pieces of paper are lying side by side, and the edges match. Now turn the two pieces edge to edge, reversing one of them. The variation from a straight line is immediately apparent, because the error is doubled. This calls for a process of trimming and continued matching of the edges in reversed positions by which edges are obtained, finally, which show no deviation. In this way two straightedges have been generated in the simplest manner possible.

This same principle can be applied to the task of making straightedges in the shop. As a starting point, take two edges that have been roughly matched, as with a file. Place these edges side by side, as at *A*, Fig. 2, and ink them with Prussian blue or other coloring material, so that when a small block or straightedge is rubbed along the inked edges, the coloring will be scraped off at the high spots, indicating where reduction is needed. When the high spots have been removed, by scraping, turn the edges so that they will meet face to face as at *B*. This shows that they are still wavy, and the coloring material will produce bearing marks as a guide to further scraping operations. Now scrape both edges in accordance with the bearing marks. This completes the first cycle of operations in generating straightedges by the use of only two shapes. The greater part of the error is already removed. Ordinary shop methods of measurement would probably reveal no error at all. It is necessary, however, to assume that error still exists, which is true of all efforts to obtain precision; in fact, it is not possible to obtain precision in any other way. Next turn the edges back to the original position, side by side, and repeat the operation as before; follow by again placing them face to face, and then by reversing one of them with its face against the other, continuing this until they fit in every position. The inevitable result is that edges are produced that are perfectly straight. This result is based on the fact that any two edges that will fit each other side by side and face to face are straight. By this method, however, but two edges are required to produce this result.

The old method is to fit the straightedges face to face only. This generates a narrow surface plate, but requires three surfaces and still does not produce a form straight in more than one plane. The surface itself may be perfectly straight horizontally, but no attempt is made to straighten it in other planes. By the new method, here under discussion, it is possible to do the work with two edges only, and to produce knife straightedges that will be straight in every plane. The latter result is obtained by making the edges fit each other at three angles, as at 0, 180 degrees, and 90 degrees, or side by side, face to face, and at right angles as at *A*, *B*, and *C*, Fig. 3. Any other angle will serve, but a right angle is preferred for the reason that it will show the maximum error. The simplest demonstration of this principle of producing edges that are straight in every plane is afforded by folding a sheet of paper. In the very nature of things this produces an edge which is straight in one plane. Held at right angles it becomes straight in every plane. In other words, the edge now becomes not merely straight in the direction of the fold, but constitutes the straight line that forms the shortest distance between the two ends.

All of us know the trick of folding a sheet of paper to make a desk ruler. The principle applied in this operation is not ordinarily used in mechanical operations, but it could be employed to advantage and do much for simplified shop practice. The principle is susceptible of wide extension. With the folded sheet of paper, for example, we know that in order to make a right angle we merely fold the sheet once more so that the edges match; this generates a true angle of 90 degrees. By carrying this idea into shop practice, we are able to generate such forms as precision squares, precision cubes, and plane parallel opposite faces. The method of producing small, narrow surface plates is the same as that em-

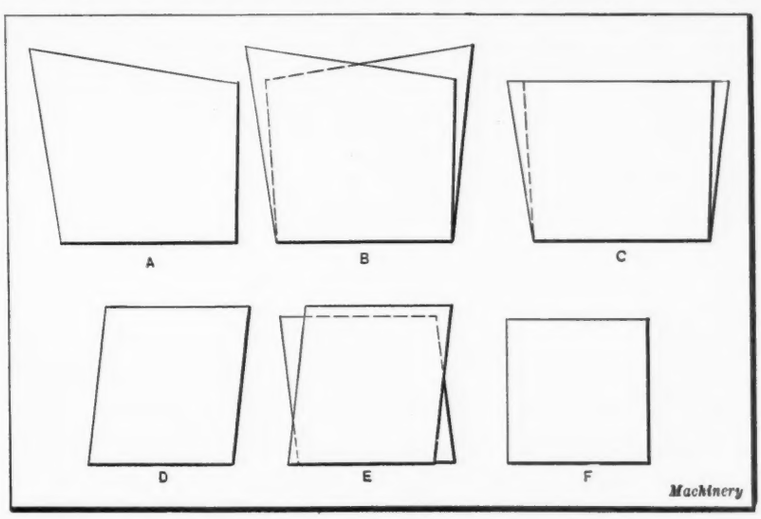


Fig. 5. Natural Method of producing Parallel Planes and Edges that are Square with Each Other

ployed in making straightedges, as a straightedge is in reality a long narrow surface plate.

Generation of Parallel Planes

The generation of plane parallel opposite faces, or two parallel surfaces, will now be considered. The making of straightedges by creating surfaces that will fit together interchangeably as just described, may be applied in principle to the generation of plane parallel opposite faces. This method has not been published heretofore. Begin with the creation of parallel lines. To demonstrate, take two sheets

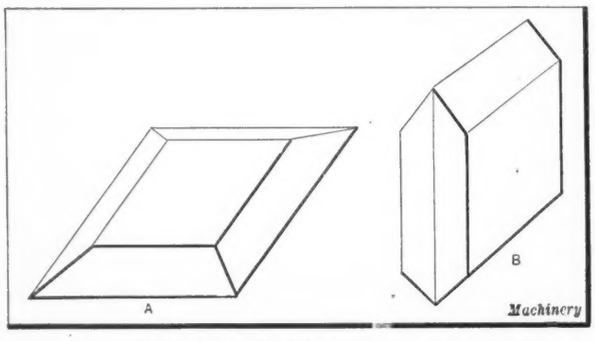


Fig. 6. (A) Knife-edge Angle-block; (B) Two Blocks arranged for generating 90-degree Edges

of strawboard which are manifestly wedge-shaped. The purpose is to change the sides of each wedge into lines which are parallel. Hold the pieces firmly side by side and match up the edges on two opposite sides by rubbing them on a sheet of sandpaper laid flat (see diagram *A*, Fig. 5). Then turn one of the pieces end for end and place it side by side with its mate, as at *B*. The fact that the edges are not parallel is immediately apparent in exaggerated form, as the error is doubled. To remove the error, the edges are again rubbed on the flat sandpaper, with the pieces held firmly side by side thus obtaining the result indicated at *C*. The interchanging and rubbing are continued until the two edges match each other, when the pieces are placed side by side and when one piece is turned end for end.

It must be borne in mind that the strawboard and sandpaper are used merely to illustrate the principle, and the results with these materials will be sufficiently close to do this. With accurate surface laps and hardened steel forms, the surfaces generated will be accurate, parallel planes. The same method may be applied to the two other edges for the purpose of making them parallel to each other. This will produce a parallelogram, as at *D*, which, however, is not square, owing to the fact that the transpositions have been 180 degrees, or half way round the circle. To demonstrate by converting the strawboard pieces into perfect squares, these pieces are held side by side and the four edges rubbed on the flat sandpaper. One of the sheets is then turned 90 degrees, as at *E*, and the four edges again

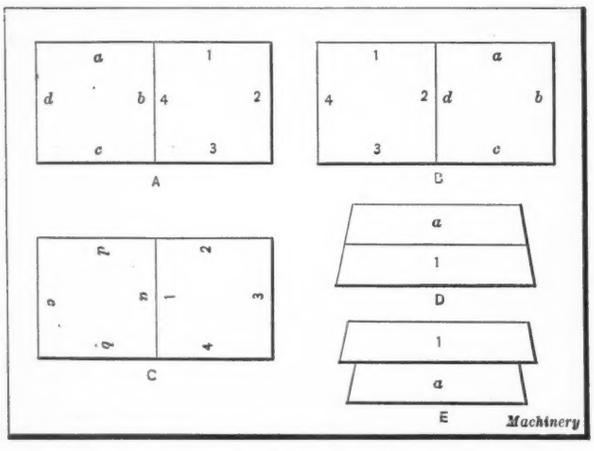


Fig. 7. Method of generating Square Blocks having 90-degree Angles and Equal Edges which are Square with the Sides

lapped on the sandpaper. The 90-degree turning and lapping operations are continued until all the edges match each other in every position, as at *F*, resulting in two pieces each of which has four equal sides and four equal angles, the latter being necessarily 90 degrees. This carries out the theorem of Euclid that the sum of the four angles in any quadrilateral figure is 360 degrees, and that if all the angles are equal each of them must be one-fourth of 360, or 90 degrees. This principle may be used in providing knife-edge squares with angles of 60 degrees, 90 degrees, or of such width as will produce a polygon of any given number of sides, all identical. It is especially interesting because it makes it possible to divide a circle into any number of equal parts—a task otherwise impossible.

Production of Angle-blocks or Squares

In making hardened steel angle-blocks, either with flat edges or knife-edges, as preferred, an accurate plane surface lap must be used for abrasion. The same methods as were explained for the strawboard and sandpaper, when carried out accurately with steel forms and a surface plate, will produce high-precision angle-blocks. In the production of knife-edge angle-blocks (see diagram *A*, Fig. 6), the operation is very easy and is conducted in the manner already described for the simpler demonstrations with cardboard. The blocks are simply placed together, as at *B*, while generating the right angles. If it be desired to produce angle-blocks with plane surfaces, it becomes necessary to make other transpositions than those previously described, in order to insure that the edges will be of proper form and will not produce a pyramidal effect.

Suppose it is desired to make two perfect squares of hardened steel, 2 inches square and ¼ inch thick. It is required that the edges be perfectly square with the sides, the angles truly 90 degrees, and the four faces equal to each other. This means that the blocks must be perfectly squared in every dimension. To accomplish this result requires either two plane surface laps or one surface plate and one surface lap. We will assume the use of the latter. The first step is to make the sides of the two pieces plane and parallel. This is achieved by laying both pieces flat on the surface plate, with two of their edges touching, as at *A*, Fig. 7. The two surfaces are then lapped with the surface lap for a period of time, after which one of the pieces is transposed from the right to the left side, as at *B*, this transposition bringing together the edges that were previously on the outside. The surface lap is then used again to reduce the two surfaces to the same plane. The same operation should be repeated after transposition of the two other edges of each piece; that is to say, the right-hand block is now rotated 90 degrees while still in contact with the face of the surface plate. The left-hand block is also rotated 90 degrees, either to the left or right. This rotation brings together edges that have not previously been in contact, as is clearly illustrated by diagram *C*. The same lapping and transposition are continued until the lap rests evenly on the entire surface of both blocks, regardless of which edges may be placed together. This proves that the surfaces have become plane parallel opposite faces.

The next operation is to lap the edges of both blocks The two blocks are placed with their flat sides together (as at *D*) and held firmly while the four pairs of edges are lapped on the surface lap. One of the blocks is now rotated 90 degrees, the edges are matched up evenly, and the four pairs of edges again lapped, as previously described. This process of turning and lapping should be continued until the edges match in every position. When this result has been reached, we have generated what is theoretically the frustrum of a pyramid with 90-degree corners.

In order to assure that the edges are truly square with the sides, as well as with each other, it is now necessary to introduce another transposition. This transposition takes the form of bringing into contact with each other the sides of the blocks that have been outside. This can be done by

removing the block from underneath and placing it on top without otherwise turning either block, as shown at *E*. When the edges are lapped in this relation, it will immediately become apparent that the edges were not square. The same method of turning one block 90 degrees while it is still in contact with the other one is continued until all the edges finish out in polishing. In other words, these transpositions and lappings must be continued until the polished edges match perfectly when turned in every position and with either side of either block in contact with its mate. This means that these blocks may be placed in any position and the edges will match perfectly. We have, therefore, produced two 90-degree angle-blocks, both with plane parallel opposite sides and with every angle truly 90 degrees—blocks that are precise in every particular.

Generating Precision Cubes

If it be desired to produce two perfect cubes, the method is practically the same as previously described for making precision angle-blocks. Blank pieces, already made approximately cubical, are used to begin with. These pieces are transposed in the various ways already outlined, bringing the several faces of each one into contact with the various faces of the other, the transpositions always being accompanied by the process of leveling up on the surface plate and continued lapping of the two adjacent upper surfaces with the surface lap. This must be repeated until the surfaces, placed against each other in any position, are found to be in the same plane when the blocks are lying on the surface plate. The prime essential in producing cubes is to see that the sides that are in contact with each other are held in full contact during the lapping operations.

By these operations two perfect cubes may be produced. Each cube contains six faces, eight corners, twelve edges, and twenty-four right angles formed by the corners. All of these have been created by the application of a simple principle. The method carries within itself the principle of accuracy which, if followed out, must inevitably result in the production of two precision cubes. Each face is a true plane of equal area with each other face. These planes intersect each other at angles of 90 degrees. All edges form straight lines of equal length, each of which is parallel to each of its mates. All angles are right angles. The sum of these factors is true precision.

* * *

MEETING OF STEEL TREATING SOCIETY

The sixth sectional meeting of the American Society for Steel Treating was held at the Hotel Sinton, Cincinnati, Ohio, Thursday and Friday, January 15 and 16. The first day was devoted to technical sessions, with an informal dinner meeting in the evening. The second day was devoted exclusively to the visiting of plants in Cincinnati and vicinity. The papers presented were as follows: "Sample Preparation for High-power Photomicrography," by R. G. Guthrie, metallurgist, Industrial Gas Department, Peoples Gas Light & Coke Co., Chicago, Ill.; "High Tensile Strengths with Low Carbon Steels," by R. H. Smith, vice-president, Lamson & Sessions Co., Kent, Ohio; "Wear and Wear Testing," by G. W. Quick and S. J. Rosenberg, Bureau of Standards, Washington; "Gearing as a Medium of Industrial Power Transmission," by O. N. Stone, assistant chief engineer, Van Dorn & Dutton Co., Cleveland, Ohio; "Corrosion Resisting Steels of the Iron-carbon-chromium and the Iron-carbon-chromium-silicon Series," by T. Holland Nelson, metallurgist, United Alloy Steel Corporation, Canton, Ohio.

* * *

The American Express Co. has arranged a South American tour for business men, known as a "good will and study tour," the itinerary of which covers Havana, Panama Canal, Peru, Bolivia, Chile, Argentina, Uruguay, Brazil, and the West Indies. The tour starts from New York on February 5, returning on May 4.

MODIFIED TYPE OF SUB-PRESS DIE

By HOWARD M. GROFF
Treasurer, Buch-Groff Co., Trenton, N. J.

Most watchmakers are familiar with the three general types of dies, namely, the open punch and die, the cylinder sub-press punch and die, and the pillar sub-press punch and die. It is the object of this article to present a type of die that is a modification of the last two types. This die, shown

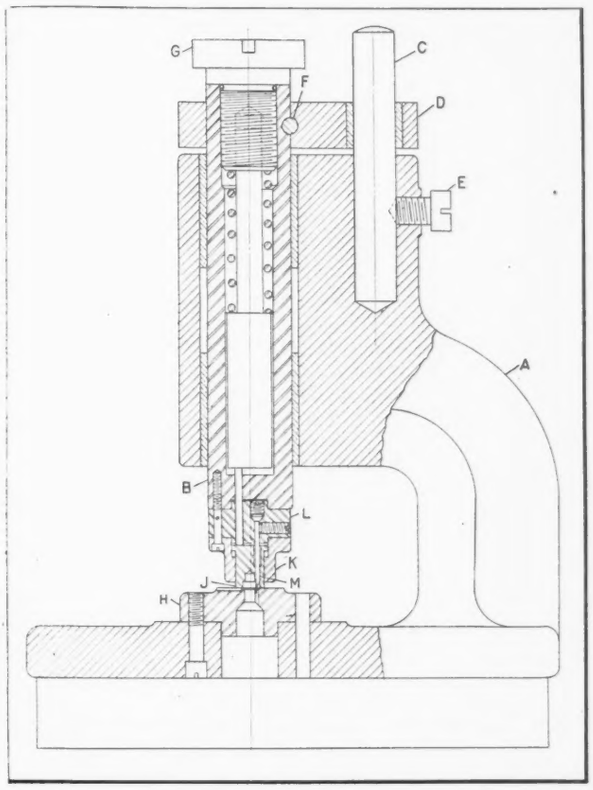


Fig. 1. Sub-press Die for shaving Hole in Watch Part

in Fig. 1, is employed to shave the triangular pin hole in a balance hub and roller which is used in high-grade watch movements. A diagram of the hole is shown in Fig. 2, and the roller may be seen at the right in Fig. 3. The delicacy of this operation will be realized when the size of the drilled hole—0.015 inch in diameter—is noted. This hole is shaved to a triangular shape 0.0252 inch wide by 0.0142 inch deep, one side of which is formed to a radius of 0.0536 inch.

It is the general construction of the punch and die to which particular attention is directed. In a great many shops, the cylinder sub-press construction is used for the parts requiring extreme accuracy as to size and relative positioning of the pierced holes with the external outline. In these cases the cylinder sub-press is of the compound type. Other types of work are produced in the well-known pillar sub-press die, where two, three, and sometimes four

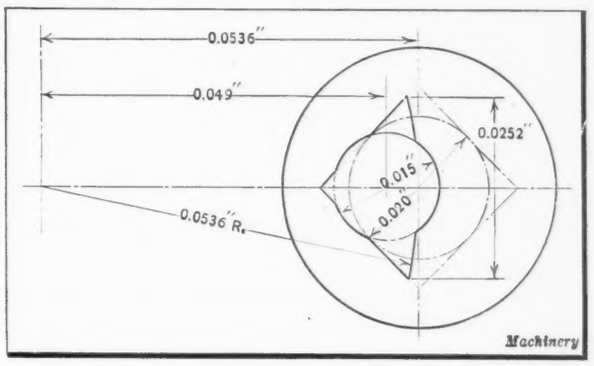


Fig. 2. Diagram showing Size and Shape of Hole in Watch Part

pillars are used to maintain alignment of the punch and die.

The die shown in Fig. 1 consists of a solid stand *A* containing the punch and the die bearings; a cylinder *B* operated directly under the slide of the press; and a pillar *C* which maintains alignment of the punch with the die located in the base of the stand. It will be noted that the details of the die shown in Fig. 3 are designated by the same reference letters as in the assembled die shown in Fig. 1. The simplicity and low cost of construction will appeal to those well versed in punch and die design. The stand, being made of one piece of ribbed design, can be mounted on a lathe faceplate, and the plunger bearing, hole, and face for the die all machined at one setting so that proper alignment is insured.

After the cylinder bearing has been bushed, the yoke *D* is secured to a standard plug to which size all cylinders are lapped. This plug enters the cylinder bearing, and after yoke *D* has been clamped securely to stand *A*, the pillar hole is machined through the yoke down into the stand. The hole in the yoke for the pillar is provided with a bushing which is a sliding fit on the pillar. The pillar itself is ground and lapped its entire length, and is a light drive fit in the stand; it is finally secured by a set-screw *E*. In the assembly, the yoke is keyed to the cylinder by a taper pin *F*, and the cylinder is provided with the usual button *G*. If an accurately trued-up faceplate is used in boring the cylinder bearing and pillar hole, no difficulty will be experienced in machining these holes parallel.

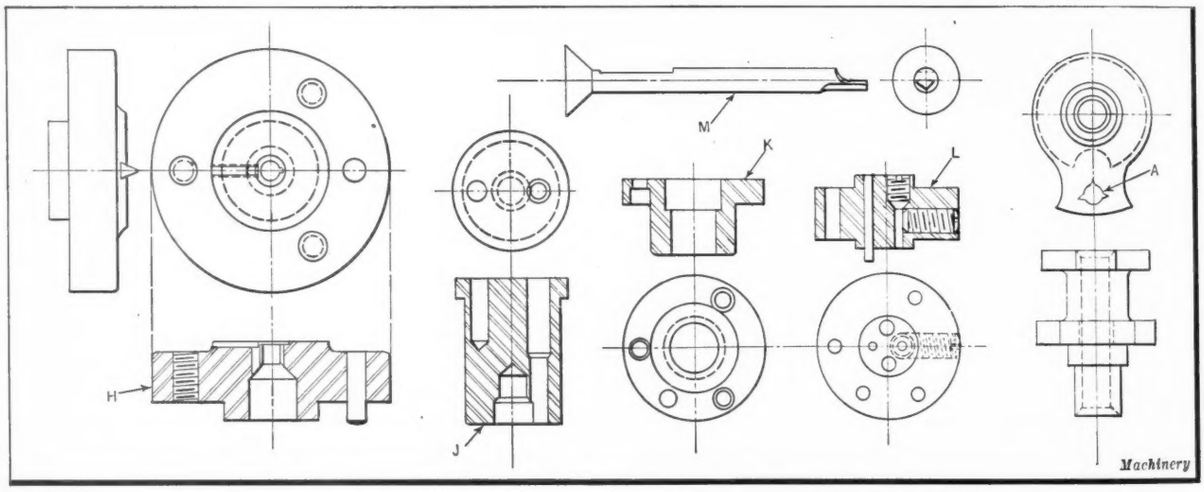


Fig. 3. Details of Die shown in Fig. 1, and Example of Work

The space between the upper and lower bushings on the cylinder is used as an oil well for lubrication. In this connection, attention is directed to a common practice in pillar sub-press design which is faulty. A great many designers provide a spiral groove on the pillars to assist lubrication. This opening affords access to grit and dirt which soon destroy the fit of the cylinder in the bushings. If hte cylinder is properly fitted and the oil supplied from an internal reservoir, all dirt and grit will be excluded from the bearings and long life insured.

This type of die is recommended for a great many press operations where a self-contained unit is desired for accuracy and rapidity in set-up, and where initial cost and upkeep are the prime considerations. It should, therefore, replace either the cylinder or the true pillar type in a great many instances.

* * *

The South American market for machine tools has never been large. However, the Brazilian market for metal-working machinery for the first nine months of 1924 showed a slight increase over the corresponding exports during 1923. The total value of the exports of metal-working machinery for the first nine months of 1924 was about $125,000, of which lathes represented $18,500.

SELECTING EMPLOYES SCIENTIFICALLY

An exhaustive and interesting report on "Public Employment Offices" has been issued by the Russell Sage Foundation, 130 E. 22nd St., New York City. This report points out that there is a great deal of quackery and pseudo-science advocated for selecting applicants for employment, and that a greater part of the experimentation that has been carried on in regard to the selection of workers is still comparable to the "home remedy" stage of medicine and surgery. The value of relying on such items as the look in an applicant's eye, the condition of his hands, or the condition of his clothes is minimized in this report, as is also the practice of arbitrarily classifying applicants for employment according to any standardized list of types of personalities—a practice that has been quite popular.

"The human mind" says the report, "has been grouped by some persons interested in employment questions into types that are presumably mutually exclusive as follows: The executive type; the detail type; the promotion type; the accounting type; the clerical type; the selling type; the mechanical type, and so on. These adjectives do describe attributes of the mind, but that people can be so tagged and labeled fairly is doubtful. The temptation to label people is very great, but the science and art of successfully doing it have not as yet been discovered."

The report is not intended to discourage research work in this field, but is a warning against depending too much upon any schemes for rating individuals, that appeal to the imagination, because of the great need for more definite methods in selecting employes, rather than because of the demonstrated success of the scheme proposed. The two directions in which progress can be most successfully made are those that are intended to define as intelligently as possible (1) the exact requirements of the job the employer wants to fill, and (2) the capability and adaptability of the individual worker applying for this job. Doubtless, common sense and judgment, rather than set rules and standardized formulas, are as yet the safest guides in meeting these requirements.

In making its recommendations for improved employment service of a nation-wide scope, the report points out "(1) that all of the existing employment agencies meet only part of the present need, and they leave the employment service demands of many important sections of the country and some important industries entirely undeveloped; and (2) that in order to reduce unemployment, and at the same time give employers the maximum assistance in securing labor, there is need for an employment system that is national in scope. None of the existing non-governmental agencies offers sufficient promise of development along these lines; nor is there at present any means of coordinating or correlating the activities of the existing agencies."

ESTIMATING THE COST OF JIGS AND FIXTURES

By WILLIAM F. SANDMANN

When the executives of a manufacturing plant consider the production of a new article, or a change in the design of something they already manufacture that will necessitate an outlay for tool equipment, the first question that occurs to them is "What will it cost?" They must have a cost estimate so that it will be possible for them to decide if the proposition will be a profitable one. In many plants the executives have been misled so often by the tool cost estimates furnished them that they have come to the conclusion that the only safe way is to add 50 or 100 per cent to the estimated cost. The result is that a proposition is rejected in some cases simply on account of the high estimates, whereas if an accurate estimate had been available the opposite course would have been pursued with profit to the company.

A prominent machine tool builder who furnishes his machines equipped complete with the necessary jigs and fixtures experienced much difficulty and the occasional loss of an order as a result of the high estimates on fixture costs. After considerable deliberation and experimenting, an estimate sheet was devised that, when used by an estimator with a fair knowledge of shop conditions, was found to provide a closer figure than any other method. There was also the additional advantage of having the complete estimate in such shape that it could be gone over and checked or corrected. With this method a rough lay-out or sketch is necessary in estimating the cost, but this, of course, is customary when any method is used.

Fig. 1 shows an estimate sheet filled out with the cost figures for a very simple pin jig. It will be noted that the column headings, "Pattern," "Mill," "Drill," etc., cover practically all the usual shop or tool-room operations. A "Miscellaneous" column is included for any operation that is not listed. A column headed "Bench" provides for the various bench operations, such as filing, chipping, etc.

The time required for each operation on every piece is estimated and entered in the proper column, in hours or the decimal part of an hour. The total time per piece is placed in the total column, and the cost of the material required to make the piece is set down in dollars and cents in the next column to the right. The sheet is in two sections so that a greater number of items can be placed on it. In the lower right-hand corner, space is provided for the totals of the tabulation. When the cost of designing is to be figured into the cost of the jig, the average rate per hour for a draftsman is multiplied by the estimated hours. In the next space, the average hourly rate for the toolmaker is multiplied by the total hours in the labor column. The next space is for the summary, and the designing, construction, and material totals are added together to obtain the grand total.

Fig. 2 shows the pin jig used as the example for the estimate sheet shown in Fig. 1. It will be noted that the first item on the estimate sheet, designated by the number 1, is the soft steel V-block. According to the data tabulated, a half hour is allowed for the toolmaker to obtain the material for this part and to center-punch the primary locating points. The toolmaker then takes it to the shaper and proceeds to true it up, cut the vee and shape out the clearance on the under side to produce the two resting pads. As this is only a rough jig the fine cross-feed of the shaper can be used to finish the vee satisfactorily so that grinding

No. 419 FOR Dept. 6. NAME Drill Jig for Pin DATE 4/26/22

Item	Pattern	Clean	Layout	Planer	Shaper	Mill	Scrape	Lathe	Grind	Drill	Tap	Bench	Ht. Treat Forge	Misc.	Total Hours	Material Cost
1			.5		3.					.3	.2				4.	$ .98
2			.5		1.					1.					2.5	.16
3								1.	.5				.2		1.7	.21
4			STOCK DOWEL													.01
5			STD. FILL. HD. SCWS. (4)													.16
ASSEM. 1.0			INSPECT .5					PAINT X							1.5	
															TOTALS 9.7	$ 1.02

DES. RATE $ .75	CON. RATE $ .60	DES. $ 1.50
EST. HOURS 2	EST. HOURS 9.7	CONS. 5.82
		MAT. 1.02
TOTAL $ 1.50	TOTAL $ 5.82	TOTAL $ 8.34

Fig. 1. Loose-leaf Sheet used in estimating Cost of Jigs and Fixtures

is unnecessary. Three hours is ample time for this work on the shaper.

The toolmaker then procures the stock for item No. 2, which is the top piece of the jig and lays it off and squares it up on the shaper. It is then taken to the drill press, where the hole for the bushing is drilled and reamed. The four holes for the fillister-head screws are also drilled and counterbored and the small hole for the stop-pin drilled and reamed. A total of two hours and a half, distributed as shown on the estimate sheet, should suffice for this piece. The toolmaker then returns to item No. 1, and locates the screw-holes from the holes in part No. 2, after which he drills and taps the holes in part No. 1 on the drill press, 0.3 hour being allowed for drilling and 0.2 hour for tapping.

A piece of tool steel is used for the bushing which is listed as item No. 3. This bushing is chucked in the lathe and turned after which an under-size hole is drilled through it while it is still in the lathe. An hour is sufficient for the lathe work on this part. The time allowed for hardening the bushing is 0.2 hour. It is estimated that the grinding and lapping operations required to finish the hole in the bushing and for fitting it in the hole in the top plate will consume 0.5 hour. This completes the estimates on the parts that are to be made.

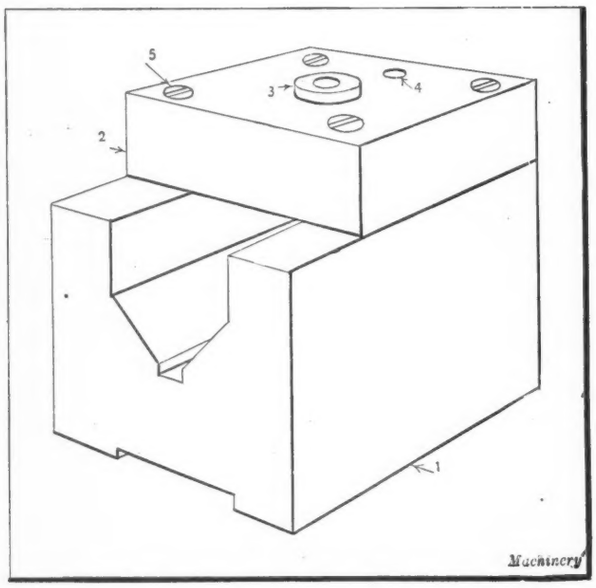


Fig. 2. Jig for which Cost Sheet shown in Fig. 1 was prepared

One hour is allowed for assembling the jig, which includes the time spent in obtaining the screws, fastening the top plate down in place, and driving in the bushing and stop-pin which is listed as item No. 4. No dowels are provided for holding the top in place, because accuracy beyond a certain point is not essential. Half an hour more is allowed for inspection, carding, and placing the jig in the tool-crib ready for use. The cost of the materials is based on their weight. The prices of stock articles, such as screws, dowels, etc., are taken from a regular price list.

Estimating the time required for designing is a matter of experience, but as the average estimator has generally done drafting work, this should cause no difficulty. The estimator is supplied with the average hourly designing and construction rate. By multiplying these rates by the hours in the space provided for that purpose, and then extending the totals and adding them, a grand total is obtained which, in this particular example, is $8.34, including the cost of the material. The estimate sheet is clipped to the sketch of the tool and is handed over to the interested parties. By adding the overhead rate (this is seldom given to the estimator) an extremely close estimate of the cost of the tool can be made. Nothing is added to this total, for the estimator allows sufficient time for each individual operation, and the overhead is generally a fixed figure.

This method might be criticized on the grounds that the estimator would have to be a highly paid man. But any estimator should know his business, and by dividing the operations, as is done on this estimate sheet, a fairly well informed draftsman can in a short time learn to estimate quite accurately the time required for any machining operation. The estimate sheets are perforated for filing, and are retained until after the jig or fixture is constructed, so that the estimate can be compared with the actual cost figures.

* * *

INDUSTRY MUST TRAIN MEN

Our failure to train men in this industry has been based on the conclusion that we could not afford to do so. It would now appear that we cannot afford *not* to do so. It is well to organize for accurate cost-keeping, selling methods, good banking connections, and all the rest of the functions necessary for the financial condition of a business; but do not neglect the base of the pyramid on which the balance of the structure rests and that is a body of sane-minded, well-trained mechanics out in the place where, in the last analysis, the money has to be produced. You will have to do it eventually, why not now?—*John C. Spence, in a paper before the National Metal Trades Association*

SALVAGING INSPECTION REJECTS

By P. H. BRYANT

When is a limit not a limit? In other words, when must a limit be strictly adhered to and when can it be set aside? This mooted question has been the cause of friction since the first tolerance dimension was written on a drawing, and it seems not much nearer a practical solution today than at the outset. Either a tolerance dimension represents an ironclad limit, inside of which all parts produced are usable and outside of which all parts are rejects for the scrap pile, or it represents so much clutter on the drawings. The minute the impression gets abroad in the shop that the limits specified on the work are closer than they need to be, and that work outside of these limits is going to be accepted with little difficulty, we might as well charge up a big percentage of the cost of operating our inspection organization to useless expense.

Inspector's Decision should be Respected

In few industrial plants are all the parts that fail to measure up to the specified tolerances during the processes of inspection disposed of as scrap. Scores of reasons are given for easing down a bit from the specifications on the blueprint, but they all simmer down eventually to the fact that the tolerances specified are too close, and that in most cases the part is "just as good for the purpose" when not too far outside these tolerances. Naturally, even slight concessions in handling the problems of rejects in the shop give rise to a general spirit of disrespect for all tolerance dimensions. It is this factor that presents the greatest obstacle to effective inspection.

In shops where the piece-work system prevails, it would seem that a practical means of eliminating or checking disrespect for the limits specified is to pay only for work that passes the floor inspector, and thus make the machine operator stand the loss on his spoiled work. In most cases, this loss is limited to the piece-work rate on the part, although in some shops the workman is assessed a certain percentage of the estimated value of the part at the time it was spoiled. However, in very few cases is the loss eventually deducted from the workman's pay. The following incident will serve to show how it usually works out.

Practice that is Unfair to Inspector

A midwestern industrial plant having a carefully organized inspection system holds each foreman accountable for the spoiled work in his department. At the end of each month the value of the material scrapped in each department is totaled, the percentage ratio to the value of good material produced is computed, and these results posted in full view of all the workmen. Let us assume that in a certain department the inspector is working with the idea that the limits are to be strictly adhered to and that during a certain day he rejects fifteen out of a hundred parts because they will not pass the "Not Go" gage.

When the division inspector comes around the next morning, he gages one or two of the rejected pieces and attaches to the parts a red tag marked "Destination—Scrap Pile." About that time the department foreman shows up and inquires: "What's the matter there?" "Rejects," says the inspector, "sending it to scrap." "I guess not," says the foreman, "you leave that stuff right where it is. If you think I'm going to have that charged up against me this month you're kidding yourself."

Sometimes they argue, sometimes the division chief, having learned from experience what the final outcome will be in such cases, washes his hands of the responsibility and walks on. During the day the foreman brings around the production superintendent and they look the rejects over. The floor inspector shows them that certain holes are oversize and allow the gage to enter. The superintendent knows, however, what the inspector probably does not, that this will not have the slightest effect on the general quality of

the completed products. Consequently he says just what the foreman knew he would say, "They're all right, let them go." The foreman nonchalantly tears up the red ticket, the machine operator looks at the inspector and grins, while he mentally adds the premiums on those fifteen pieces to his previous day's earnings, and the inspector goes back to his work cheapened and disheartened.

This is a typical example and not an exception. In this plant of some forty-five departments employing 2500 men, the same little comedy with slightly different settings and principals is enacted scores of times every working day. But in the face of this unending controversy as to what is theoretically correct and what is practically usable, this plant's inspection system and the practice of setting definite tolerances in the drafting-room has resulted in a marked improvement in the quality of the product.

Conditions such as described provide no argument against limiting dimensions and establishing efficient inspection systems, but they present the natural human obstacles that tend to prevent the smooth working of a system that is desirable from every standpoint. If such systems cannot be carried on without constant controversy between the inspectors and producers, they should, nevertheless, be continued, because the benefits accruing in spite of the controversies overbalance their drawbacks. If, however, some plan could be worked out which would eliminate the friction that exists at present and replace it with a spirit of co-operation, it would be a great benefit to industry. The writer will not attempt to offer a solution to this problem, but will only indicate the lines along which he believes such a solution must be worked out, and possibly offer a suggestion or two in that direction.

Result of Selective Assembling

First let us investigate the methods already tried. One of the first steps forward was the development of selective assembling. This was a concession to the production branch in that it resulted in increased tolerances. But it did not provide an effective solution to the problem, because tolerances were still required and the same human characteristics that prompted an operator to overstep the original limits soon bred a contempt for the broader ones. Selective assembling relieved the situation tremendously, but did not reach the source of the trouble, because it did not remove the incentive to take chances on overstepping the limiting dimensions, whenever it became a matter of personal pride or profit to do so.

Another expedient that was given a thorough tryout, especially on war work, was to establish two sets of limiting dimensions—one a working set for the shop and operator, the other, a supposedly secret set for the use of the inspectors. This plan had great possibilities and would have given beneficial results, but for the fact that it was found impossible to keep secrets in a shop.

One clearly defined principle has developed from these experiments, however, that must form a basis for the ultimate solution of inspection difficulties. This principle is that the limiting dimensions put on the drawings are an unalterable measure of the quality of the product. So far as producer and inspector are concerned, a part that is processed within these limits is good material, but outside these limits it is scrap. The foreman's job should be to maintain a standard of workmanship in his department that will keep the product within the limits specified, and he should be allowed to have no interest in the disposal of rejected or scrapped parts. The individual operator should be hired to machine parts within the specified limits. His piece-work price—if a piece-worker—should be based on the normal productive capacity of his machine when operating within the limits specified. No credit system or honor roll that can be devised can be beneficial if it encourages an interest in the disposition of unfit material and permits a foreman or operator to clear his record of past mistakes or errors by using his influence to get rejected material passed on as O. K.

Disposal of Rejected Material

Rejected material should go directly to what, for want of a better name, we may call a department for "Rejected material salvage." This should be a separately organized department having no relation to either production or inspection. It should work very close to the broad business interests of the corporation, and the standards by which all material is finally passed upon should be worked out in terms of utility rather than in thousandths of an inch.

The writer is aware that this scheme is incomplete, that it leaves open the question of responsibility for what may happen from the use of such rejected material, or how such material is later to be identified as distinct from the regular product. Moreover, the salvaging of a considerable percentage of the material might involve correcting operations that would route the material back through the production department where it was rejected, a process that might easily precipitate its own problems of disorganization.

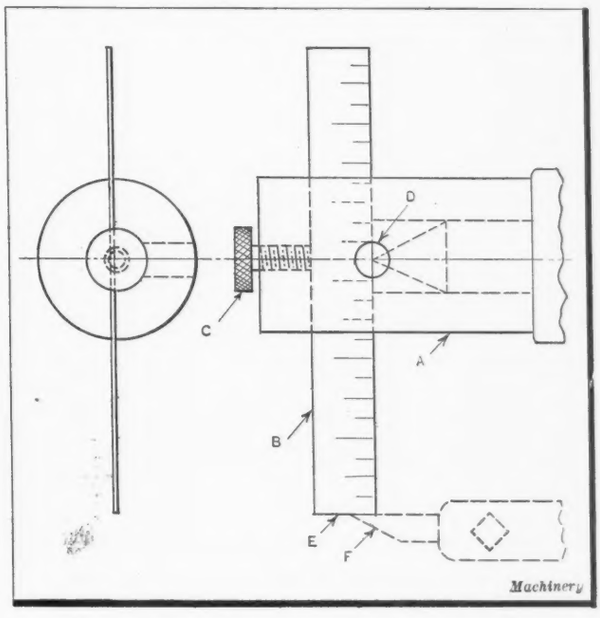
But as previously stated, the purpose was to emphasize certain principles on which future development might be based, and the writer is convinced that these principles demand the establishment of unalterable tolerances or limits for dimensions and the separation from both the production and inspection departments of all interest or responsibility for the disposition of material that is below the standards.

* * *

LAYING OUT BOLT-HOLE CIRCLES

By HARRY MOORE

The device shown in the accompanying illustration is used in locating the lathe tool for scribing the lay-out circles for bolt holes in flanges and similar work in which a number of evenly spaced holes must be drilled. A time-saving device of this kind will be found especially useful in plants where the quantity or variety of sizes produced does not warrant the use of drill jigs. Referring to the illustration, the body *A* is a piece of round stock bored out to a good sliding fit on the straight portion of the tailstock center. The machinist's scale *B* is adjustable in a slot cut in the body *A*, and can be clamped in place by means of the knurled-head screw *C*. A hole *D* drilled in the side of the holder gives the workman a clear view of the graduated edge of the scale and the pointed end of the tailstock center so that the scale can be set with its end *E* at any desired distance from the axis of the lathe spindle. After the scale has been adjusted and the screw *C* tightened to hold it in place, the end *E* serves as a fixed guide or stop for locating the point of the circle-scribing tool *F*.



Device for setting Tool to scribe Circle of Given Diameter

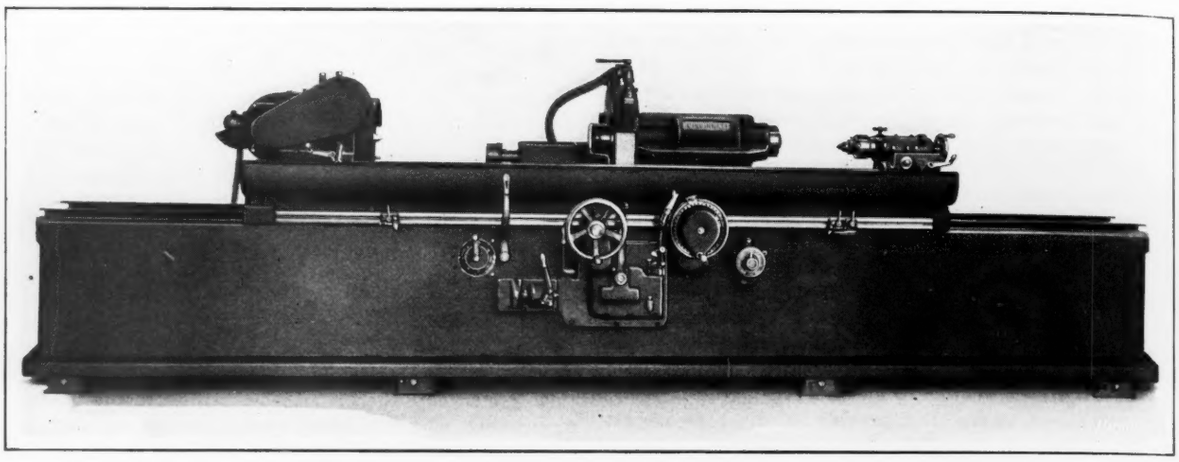


Fig. 1. Front View of Cincinnati Self-contained Plain Cylindrical Grinding Machine with Splash Guards in Place

New Self-contained Grinding Machines

SELF-CONTAINED plain cylindrical grinding machines of 12- and 16-inch swing are now being placed on the market by the Cincinnati Milling Machine Co., Cincinnati, Ohio, for grinding the larger classes of work that can be revolved on dead centers, such as spindles, car axles, motor and generator shafts, tubing, crankshaft and camshaft line bearings, and small rolls. In addition, when the machines are equipped with journal rests, a wabbler driver, and a cambering attachment, they may also be employed for grinding heavy rolls of the types used in rolling mills. Each size of machine may be furnished with beds of seven different lengths, ranging from 36 to 168 inches.

The machines are designed on the principle of a fixed wheel-base and a moving work-table. Simplified construction is obtained by casting the base in two parts, one comprising the water tank and wheel-slide pedestal, and the other, the main bed, which carries the sliding table. Bolts and a tongue and groove are used to hold the two castings together. Bases up to 6 feet long have a three-point bearing by means of feet cast on the bottom, but bases 8 feet long and over are provided with adjustable leveling wedges to compensate for unevenness of the floor or foundation.

Details of the Motor Drive

All motors, shafts, and driving mechanisms are mounted in the machine itself, forming a self-contained drive. With this arrangement, the entire machine can be readily transposed from one position to another. The motor for driving the work is mounted in the headstock housing, and the main driving motor is placed partially in the machine base and supported by it. As may be seen from Figs. 3, 4, 5, and 6, the motor is secured to the base by means of a circular adapter on the pulley end of the motor which carries a ring flange. This flange is bolted directly to the bed. With this construction the motor is accessible for adjustment and repair, and can be readily removed. A motor of 20 horsepower capacity is recommended. The drive from the motor to the wheel-spindle driving pulley is by means of an endless belt which is held in tension by idler pulleys. Although a motor drive is preferable, the machines may also be equipped with a belt drive, in which case tight and loose pulleys are carried in an outboard bearing mounted on the base. The headstock motor is from 1 to 2 horsepower capacity, depending on the size of the machine.

The Various Controls

All speed-changing and other controls are embodied in the machine within convenient reach of the operator from his normal position, and all levers and handwheels are so located relative to each other and to the machine as to afford liberal clearance for the hands. The table-reversing mechanism is of the load-and-fire type, a tarry clutch being incorporated that permits an instantaneous or a timed reversal of the table. When the power traverse table clutch is thrown into engagement, the hand traverse clutch is thrown out and the handwheel remains stationary. Con-

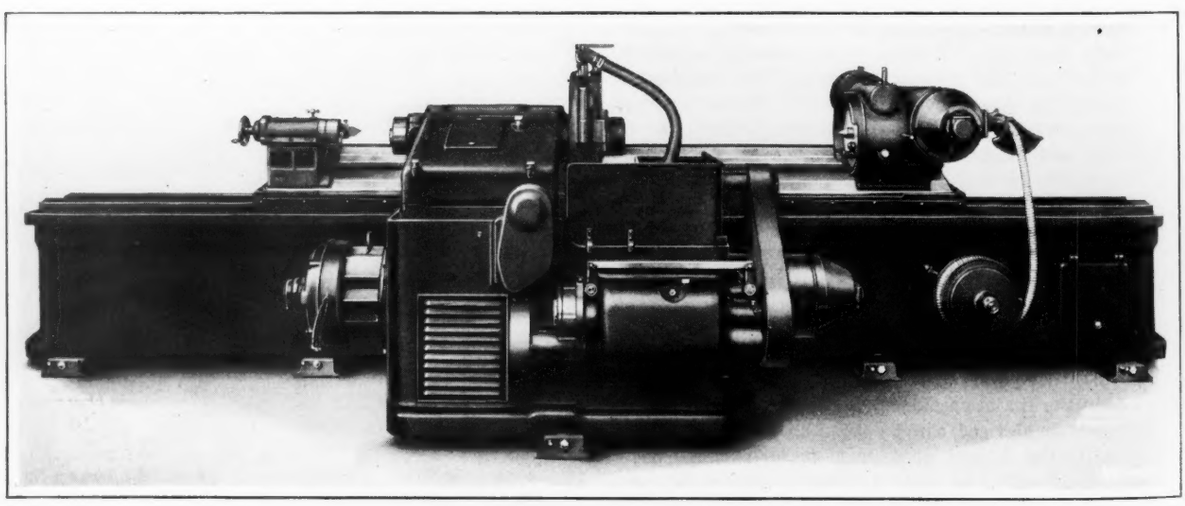


Fig. 2. Rear View of the Cylindrical Grinding Machine, showing the Positions of the Main Drive Motor and Generator

versely, when the power traverse is made inoperative, the handwheel clutch automatically becomes operative.

The speed-changing mechanism for the table reverse is of the sliding gear type, and is mounted in a box secured to the base, while the headstock spindle speeds are controlled from a rheostat, mounted on the front of the machine. Thus, the wheel and table speeds are entirely independent of each other and of the wheel speed, which affords a combination of slow traverse and high rotative speeds, or the reverse. It also permits traversing the work the full width of the wheel face at each revolution, which is often desirable in removing stock rapidly. A single lever controls the revolution of the work and the travel of the table in conjunction with each other, and hence the work and table may be started or stopped simultaneously. There are twenty-four work speeds and six table speeds.

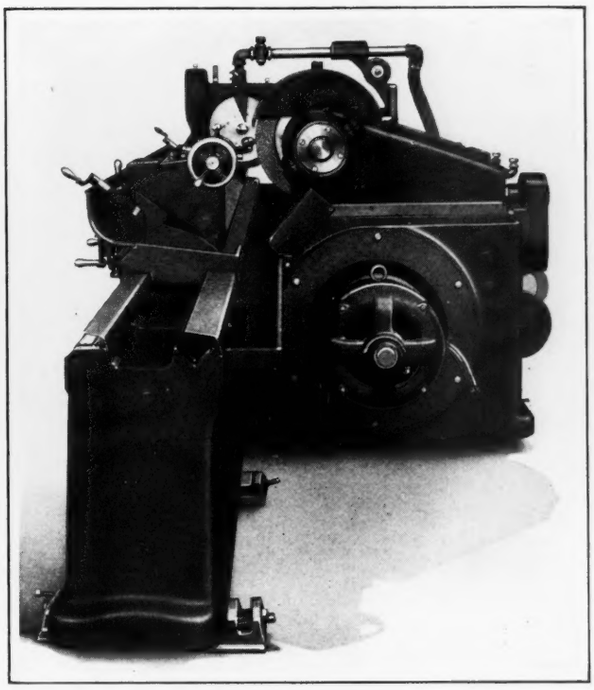


Fig. 3. Right-hand End View of the Machine

The cross-feed mechanism for the wheel-slide is mounted on the bed, and provides a diversity of changes from one of sufficient fineness for producing a high finish to one of suitable coarseness for removing stock rapidly. The mechanism may be operated either by hand or automatically by power. There is an adjustable positive stop that facilitates the grinding of duplicate diameter work when feeding manually. The power feed is automatically thrown out after the work has been reduced to a previously established size.

Construction of the Tables

The sliding table reciprocates on one flat and one vee of the main base casting, the movement being controlled by adjustable dogs operating against a reversing lever which actuates the load-and-fire clutch. Power is transmitted through worm-gearing to insure a smooth and uniform motion. The reversing dogs provide the fine adjustment necessary when grinding to shoulders, permit traversal of the table beyond the points of reversal without disturbing its initial setting, and readjust themselves after the table has been returned to its original position. A swivel table of the angular type is clamped to the sliding table at each end. It pivots on a central stud so that it can be set for grinding tapers without throwing the headstock and footstock centers out of alignment. Graduations facilitate the setting. A gap table can be substituted for the sliding and swivel tables, the minimum length of gap being 6 inches, and the maximum, 36 inches. The maximum swing in the gap of the 12-inch machines is 19 inches, and of the 16-inch machines, 23 inches.

The Headstock and Footstock

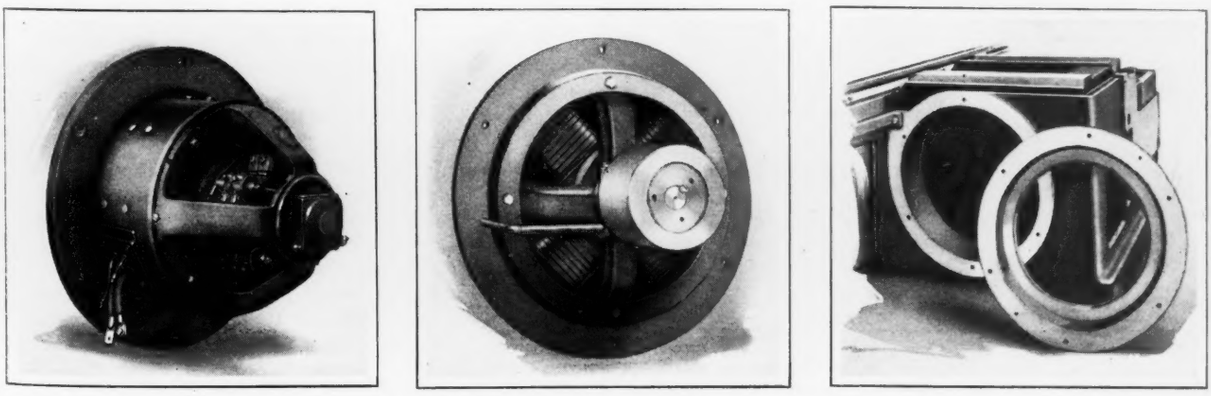
The headstock is adjustable on the swivel table and locked to it by means of two large bolts and clamps, the clamps fitting into a table slot. The spindle is hardened and ground and is placed directly over the center line of the base way that is closest to the grinding wheel. This means that there is always a support directly under the work. Power is delivered from the headstock motor to the driving plate through a silent chain, sprockets, and worm-gearing. When direct-current electricity is not available, a generator is mounted on the bed on the side opposite to that on which the main driving motor is located.

The footstock is adjustable on the swivel table similarly to the headstock. For truing the wheel without removing the work, a diamond tool holder can be used on the footstock. The spindle may be actuated by a screw and handwheel or by a quick-acting lever.

The Wheel-slide and Spindle

The wheel-slide is held on ways of the wheel-slide platen by its own weight, supplemented by the downward pull of the spindle belt. The slide is counterweighted to compensate for backlash, and this prevents the possibility of jumping in when delicate adjustments are made or of lifting under heavy cuts. The V-way for this slide is approximately central between the spindle pulley and the grinding wheel so as to neutralize any tendency of the slide to skew on the ways. The platen is cast integral with the wheel-slide pedestal and the water tank. The wheel-spindle is made from a heat-treated chrome-nickel steel forging. As illustrated in Fig. 7, it runs in bearings of the half-box type, the bodies of which are iron castings.

The bearings are lined with white metal locked in place by means of dovetail slots cut axially and circumferentially around the body. The spindle is held in the bearings by the downward pull of the belt, as the drive is direct from



Figs. 4, 5, and 6. Illustrations showing how the Motor is attached to the Bed

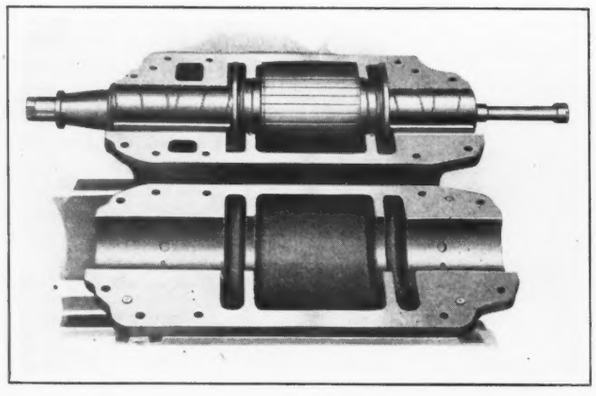


Fig. 7. Construction of the Wheel-spindle and its Bearings

a constant-speed shaft immediately under the spindle. End thrust is taken by a double thrust ball bearing, and an adjustment for end thrust can be made in a few seconds while the spindle is running. A wheel guard made from boiler plate welded together is adjustable along the wheel-slide to suit different diameters of wheels. It is provided with a series of baffles that break the water splash and spray. An aperture in the bottom allows water to escape into a settling pan and then into a tank from which it is recirculated.

Lubrication throughout is accomplished by accessible means. The ways of the base are lubricated from oil reservoirs fitted with spring rollers; the headstock worm-gearing runs partially submerged in oil; the wheel-spindle is automatically lubricated by disk-type splashers that dip into oil reservoirs; oil is distributed to the various bearings of the table speed-change box and the automatic reverse plate from a reservoir through tubing; and the reverse plate clutches run in oil.

* * *

BABBITT DIES FOR FORMING PERCOLATOR SPOUTS

By ROBERT MORRIS

The forming punch and die shown in Fig. 1 was recently built by the writer to meet the requirements of an inexpensive die for forming percolator spouts from sheet aluminum blanks. The punch and die proper were both cast from hard engine babbitt metal. The projecting part *A* of the punch and the body *B* are one solid piece of cast babbitt.

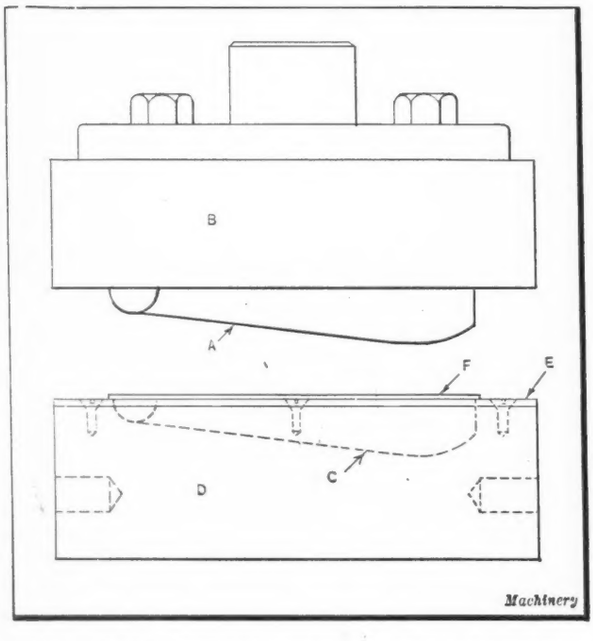


Fig. 1. Forming Punch and Die made from Hard Engine Babbitt

The die *D*, with the forming cavity *C*, is also of cast babbitt. A steel plate *E* having an opening that corresponds with the profile of the cavity *C* is secured to the babbitt die *D* to prevent the edges of the die cavity from breaking down. The aluminum blank *F* is located on the lower die by four spring stop-pins (not shown in the illustration).

In Fig. 2 the aluminum pattern *G* is shown in place in the flask or wooden frame in which the punch and the die are cast. It may be mentioned here that the punch and die shown in Fig. 1 are designed to form the left-hand half or side of the percolator spout. The construction of the punch and die for the right-hand side, however, is exactly the same except that it is made right-hand instead of left-hand. The wooden frame *W*, Fig. 2, in which the die and the punch are cast is made from ⅞-inch pine, the height being equal to the combined heights of the two dies. The metal straps *H* and *J*, secured to the top of the frame, are tapped to receive the 5/16-inch pins *K* and *L* which hold the pattern in place when the babbitt is being poured. The inside of the wood frame is coated with graphite in order to keep it from being burned by the hot metal, which is poured at a comparatively low heat. The aluminum pattern *G* is painted

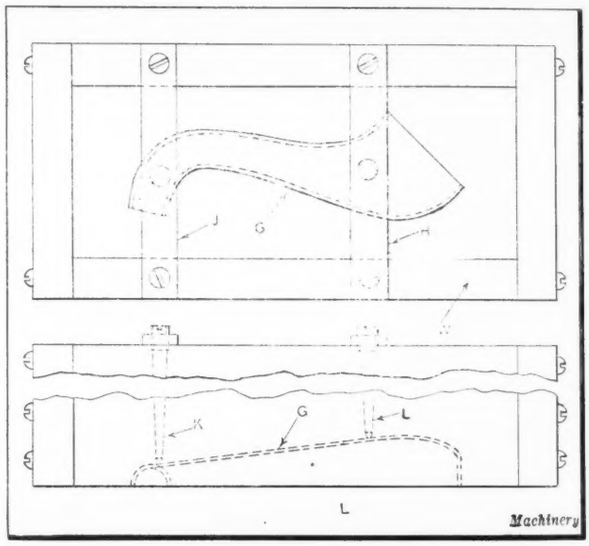


Fig. 2. Method of casting Babbitt Die

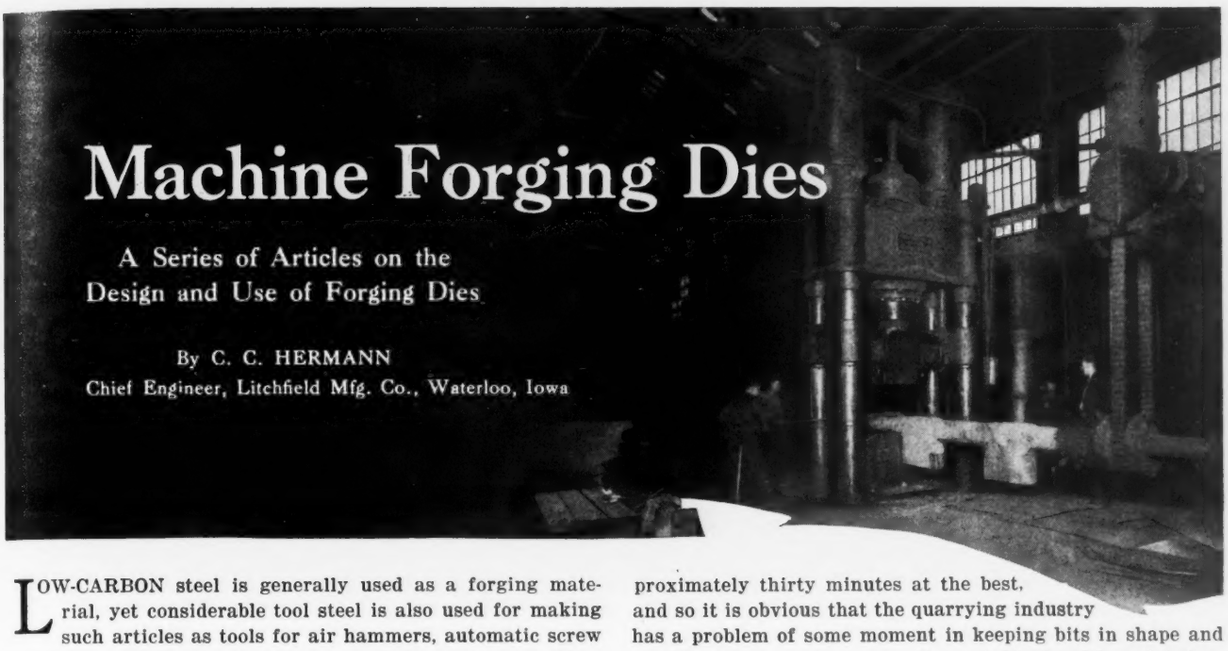
with whiting to give the cavity in the die a smooth surface. The inside of the pattern is filled with fireclay in order to keep the molten metal out.

After pouring the die member, the plate *E*, Fig. 1, is secured to its face, and the wood frame placed over it so that its sides extend above the upper face for a distance equivalent to the depth of the punch *B*. A piece of oiled drawing paper is then placed on the top of steel plate *E*, after which the upper or punch member of the die is poured. In pouring the metal, two ladles are used, the metal being poured in at each end so that the air bubbles will rise at the center of the frame and thus eliminate the forming of air pockets on the surface of the pattern. The upper face of the punch and the bottom face of the die are then machined parallel and the sides straddle-milled.

The time required to cast the two right-hand punches and the two left-hand dies, perform the machining operations, and scrape and fit the parts together, was 39½ hours. The two formed sides of the percolator spout are assembled and gas welded, the flash or flange being trimmed off after welding. The large end of the spout is clamped to a wooden form block and the end radius milled to fit the angular surface of the percolator body. The final operation on the spouts is that of polishing and buffing.

* * *

Eighty-seven per cent of all the automobiles and motor trucks in the world are in use in the United States.



Machine Forging Dies

A Series of Articles on the Design and Use of Forging Dies

By C. C. HERMANN
Chief Engineer, Litchfield Mfg. Co., Waterloo, Iowa

LOW-CARBON steel is generally used as a forging material, yet considerable tool steel is also used for making such articles as tools for air hammers, automatic screw machines, and boring machines; anvil facings; auger bits; broaches; heading and forging dies; drills; and the ordinary assortment of blacksmith's tools. The term "tool steel," as used here, includes water-hardening tool steel, which is frequently referred to as carbon tool steel, high-speed steels, and other alloy steels.

The low-carbon alloy steels generally used in forging include nickel, nickel-chromium, and chrome-vanadium steel. These alloy steels have largely taken the place of ordinary low-carbon steels when the parts are to be heat-treated and when greater strength, toughness, and fatigue-resisting qualities and a higher elastic limit are required. As explained in a preceding article of this series, tool steels require a somewhat different handling in forging from low-carbon steels, because the greater the percentage of carbon, the harder the steel and therefore the heavier the hammer blows required to forge it. The beginning of the present article will deal with forging in the field of tool-steel rock drills, and the remainder will describe the methods followed in upsetting bolts and the spokes of steel wheels.

Forging a Tool-steel Rock Drill

Fig. 1 shows the working end of a 6-inch rock drill forged out of a water-hardening tool steel having a carbon content of from 0.70 to 0.80 per cent. The steel is heated for the forging to between 1400 and 1600 degrees F. It must be heated uniformly throughout and soaking carefully avoided; in fact, soaking should be avoided with all steels. This type of rock drill was developed by the Armstrong Mfg. Co., Waterloo, Iowa, to whom the writer is indebted for a number of illustrations and part of the data presented in this article. In drilling a hole through rock with this bit, it is common practice to constantly raise and drop the bit in the hole and by giving it an eighth of a turn with each lift, it is made to cut through much faster. The center of the cutting edge is hollowed out 1¾ inches, leaving a small core at the bottom of the drilled hole which is broken and powdered by the impact as the bit drops.

A tool-steel bit working in rock lasts approximately thirty minutes at the best, and so it is obvious that the quarrying industry has a problem of some moment in keeping bits in shape and machinery in constant operation. A blacksmith and helper are ordinarily kept busy in resharpening four average bits an hour by hand methods, and under the best conditions, which are not always possible in the field, a smith cannot resharpen more than two an hour of the 6-inch size. To permit a more accurate and quicker dressing of bits in the field, the Armstrong machine shown in Fig. 2 was developed.

C. C. HERMANN, author of the articles on "Machine Forging Dies," which have been published during the past year in MACHINERY, was born in Havana, Ill., in 1889. He received a mechanical engineering education, and is a registered engineer under the laws of the state of Iowa. He served an apprenticeship in the shops of the Parlin & Orndorf Co., Canton, Ill., and at the Moline Plow Co., Moline, Ill., and since that time has been employed by Deere & Co., Moline, Ill., and by the Litchfield Mfg. Co., Waterloo, Iowa, having held positions as draftsman and designer, production manager, chief engineer and superintendent of production; when this series was started he was chief engineer of the Litchfield Mfg. Co., but he is now engaged in business for himself as a consulting engineer.

The base of this machine consists of two 8-inch channel irons set in a concrete base and securely held together by ½-inch plates along the bottom. On the top flanges at one end of the channel irons are mounted notched forgings with the straight faces of the notches toward the front. Matching the notches is a yoke casting designed to carry the upper end of the bit in the forging operation. The forward end of the channel-iron frame supports a hammer head and a die made of chilled steel, the head being connected to the arm of a crankshaft by means of a semi-elliptic spring. The head travels in a cross-guide and has a stroke of 8 inches.

Before heating the bit, a ring or collar die is slipped to about the middle, as shown in Fig. 2, and a cap is screwed on the joint end to protect the thread, as shown. The front end of the bit is then swung into the furnace by employing the jib crane. As soon as the bit reaches the proper temperature, it is withdrawn from the furnace, the collar die slipped into place over the cutting edge, and the bit lowered into the forging machine. The collar die fits a niche in the forward part of the machine and the upper end of the bit rests in the yoke, as shown in Fig. 3, the yoke being adjusted into the proper notch depending upon the length of the bit. The operator next pulls the lever as shown, to engage a clutch and put the hammer in action which, at the rate of 500 blows per minute, forges the bit back into the collar die and forms the end.

The construction of the hammer die is shown in Fig. 4, from which it will be seen that it is provided with projections *A* which fit the groove of the drill and maintain the groove form during the dressing operation. The center cutting edge of the drill is formed by V-groove *B*, and the

cheeks are shaped by flats *C* which give a slight angle to these portions. The central hollow portion of the drill is formed by the raised parts *D* of the die which are connected by fillets to projections *A*.

During the process of dressing, the hammer is periodically stopped, and the bit rotated a half turn in order to insure uniformity of the dressing. The time required for the complete operation is about two minutes. Only one heating is necessary, but when the operation has been accomplished, the bit is returned to the furnace to be heated prior to tempering. The bit is ordinarily quenched in rain water, but a bath made up of sal ammoniac, saltpeter, sulphuric acid, powdered borax, and rain water is preferable. The machine, in the ultimate analysis, is a horizontal forging machine or spring hammer utilized in a novel manner. The example shows that a difficult task under normal field conditions can sometimes be done cheaply and efficiently.

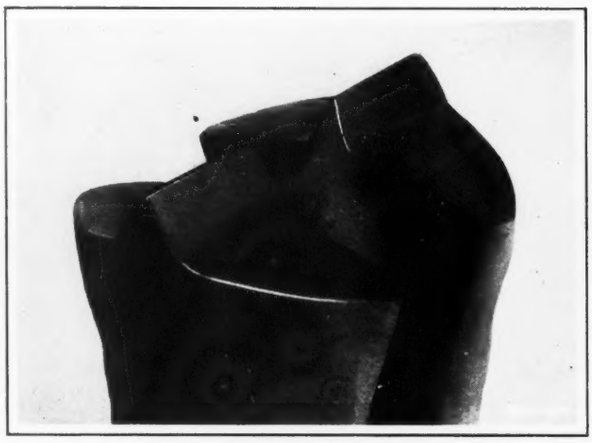


Fig. 1. Cutting End of Rock Drill reconditioned in Forging Machine shown in Figs. 2 and 3

The results obtained in forging depend to a considerable extent upon the conditions under which the steel is heated. In the field it is usually necessary for the blacksmith to judge the temperature of the work from the color, instead of determining it by pyrometric methods. For this reason a complete color chart is indispensable, but the accuracy with which the temperature of steel can be judged by the color also depends upon the light in which the work is being done and the physical condition of the work. Hence, this means of temperature measurement is merely approximate, and should only be used in the absence of instruments.

The hammer and collar dies are ordinarily made from water-hardening tool steel containing from 0.70 to 0.80 per cent carbon. However, an alloy steel may also be employed. The life of the dies depends considerably upon the manner in which they are used and particularly upon the temperature of the die faces during the forging operations. With a straight-carbon tool steel die, the preferable temperature of the face in working easily forged steel is from 400 to 500 degrees F. Under this condition it shows satisfactory resistance to wear. An alloy steel die should be used at a temperature around 850 degrees F., unless the die contains tungsten, in which case the temperature should be kept down to about 100 degrees F. Much damage may result to a die from placing it under duty while cold, and for this reason it is advisable to first heat the face. The ordinary method of heating is to use a blow-torch, taking care to heat uniformly so as to guard against starting a crack by unequal expansion.

Heading or Upsetting Operations

Heading or upsetting is a forging operation performed in a machine variously called a forging, bolt-heading, and collaring machine, depending on the operation that the particular machine is intended for. The operation is sometimes performed cold, but more often hot, as a cold upset is likely to leave the steel in a highly stressed condition, which will result in rupture when the part is further stressed in use. This is also true when a low-carbon steel is worked at a temperature lower than that corresponding to a cherry red heat. It is preferable in all cases to maintain the temperature of the stock during the forging at or near the welding temperature.

A set of bolt heading dies for use in an upsetting machine is shown in Fig. 6. Parts *A* and *B* constitute gripping dies one of which is held stationary in the machine, and the other moved laterally relative to the travel of the heading tool. When the dies are for round stock, the simplest method of producing depression *C* is to clamp the two blocks together with a piece of No. 16 sheet steel between them,

Fig. 2. Heating the End of the Rock Drill prior to Reforging

Fig. 3. Position of Rock Drill in the Machine while Forging

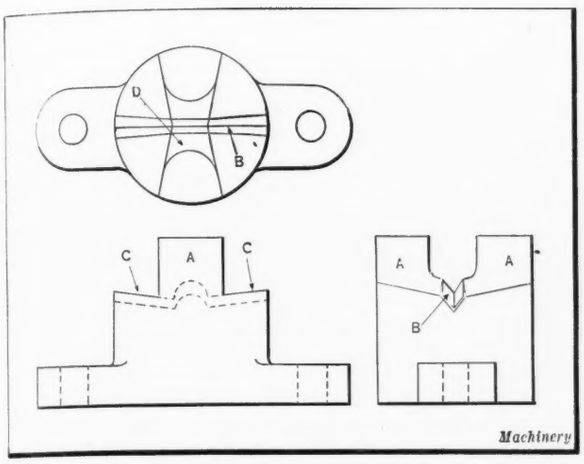


Fig. 4. Construction of Hammer Die used in reforging the Rock Drill

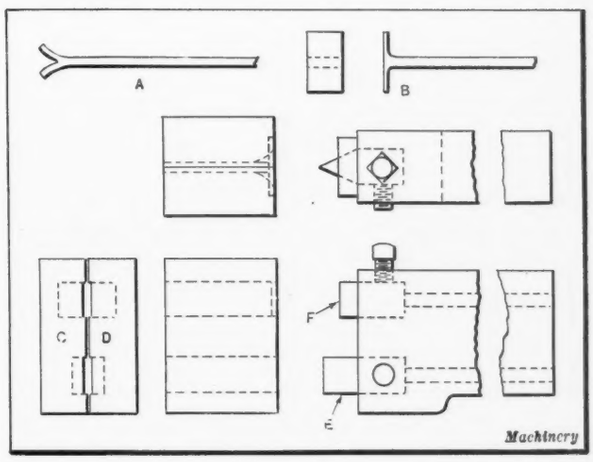


Fig. 5. Tools used in splitting and flattening the End of Wheel Spokes

and then drill the hole and ream it to size. Recess *D* is made in a similar manner, but as recess *E* is square it must be shaped or milled in the dies after drilling a number of small holes on a line with the bottom of the recess so as to provide clearance for the cutter.

The ram tool is shown in the lower part of the illustration, from which it will be seen that the tool-holder *F* is furnished with a shank for securing it in the ram. To compensate for wear, the recess for the intial heading operation is milled large enough to receive collar *G* and bumper plate *H*. Hence, as collar *G* and plate *H* become worn, they need only be replaced instead of the entire tool-holder. The heading die *J* is a separate block, shaped to suit the requirements, which is set within collar *G* and backed up by plate *H*. There is no tendency for die *J* to come out of the collar, as the fit is made close; however, the collar is attached to the holder by means of a set-screw. The trimming punch *K* corresponds to the trimming recess *E* of the gripping dies. This punch is also held in the tool-holder by a set-screw, and is removed by applying force through the overhead opening in the holder. Die *J* may be removed from the tool-holder by driving a small-diameter rod into the hole drilled through the shank.

In the heading operation, the heated stock is first gripped in recess *C* of dies *A* and *B*, this recess being in front of heading tool *J*, and then the plunger advances against the end of the stock and causes it to fill the depression in front of tool *J*. As the plunger recedes, the gripping dies release the work, and it is then placed in position for the finishing operation, which consists of trimming the flash from the head. This step is performed as plunger *K* pushes the stock into recess *E*. Recess *D* is made slightly larger than the diameter of the stock, so that the latter may move with the plunger in forcing the square head into recess *E*. When the plunger again recedes, the bolt is finished, as far as the heading operation is concerned, and is ready for cutting or rolling the threads. Parts *G*, *H*, and *J* are made of tool steel, hardened and tempered, while the holder is forged from mild steel and machined to size.

Upsetting Flat Stock

As illustrated in Fig. 5, the upsetting machine is not confined to working round stock; in this illustration are shown the dies used in producing a wheel spoke from flat material. The end of the bar is first split as shown at *A*, and then spread and flattened as illustrated at *B*. There are two recesses in the gripping dies *C* and *D* and two plungers *E* and *F* in the tool-holder. The lower plunger *E* is essentially a hot chisel used to split the end of the bar. The gripping dies, in this case also, consist of two halves, and one of them is held stationary in the machine, while the other is movable, as described in connection with the bolt-heading dies. The upper recess of the gripping dies accommodates the spread portions of the spoke as they are flattened by tool *F*, and the lower recess provides space for the entry of the hot chisel in splitting the stock. The stock is prevented from end movement by a back-stop (not shown), which abuts against the end of the stock. The width of tool *E* is equal to the length of the taper chisel part, so that the split portion of the rod is spread sufficiently to flatten out readily under the pressure of tool *F* in the next step. The length of the chisel portion is equal to the distance that the work is split.

Manufacturing Steel Wheels

Another interesting example of upsetting is found in the manufacture of the steel wheel shown in Fig. 7. The hub is an iron casting in which a series of holes *A* is drilled radially, and staggered, at an angle to the central axis of the hub that will cause each spoke to intersect the center line of tire *B*. The hub is cast with recesses *C* to provide clearance between the inner upset end *D* of the spokes and the axle of the vehicle on which the wheel is used. The spokes are also shouldered against the outside of the hub, as shown at *E*, and upset at the outer end beneath the tire, as shown at *F*, and on top, as indicated at *G*. The tire is flanged on each edge and has a depression around the entire outside for the purpose of permitting the upset outer ends to come within the extreme circumference of the wheel. The spokes illustrated are round in cross-section, although material of any cross-section may be used in the same way. The chief aim in the manufacture of steel wheels of this type is to obtain a wheel in which all spokes are in tension rather than in compression.

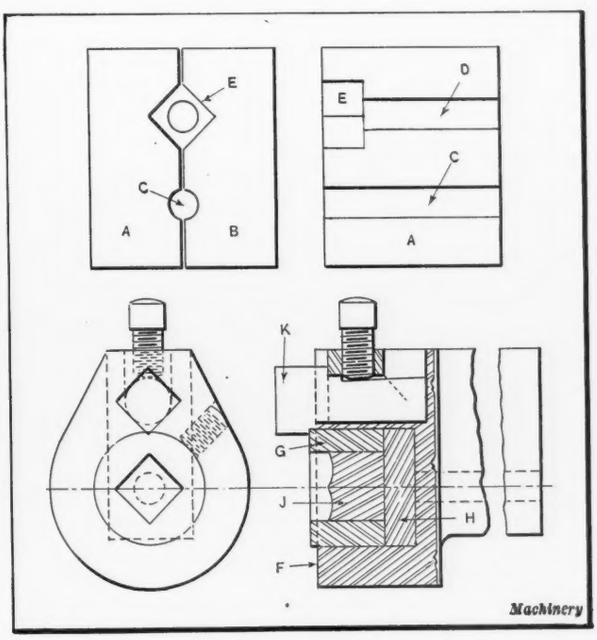


Fig. 6. Die Equipment employed in upsetting a Square-head Bolt

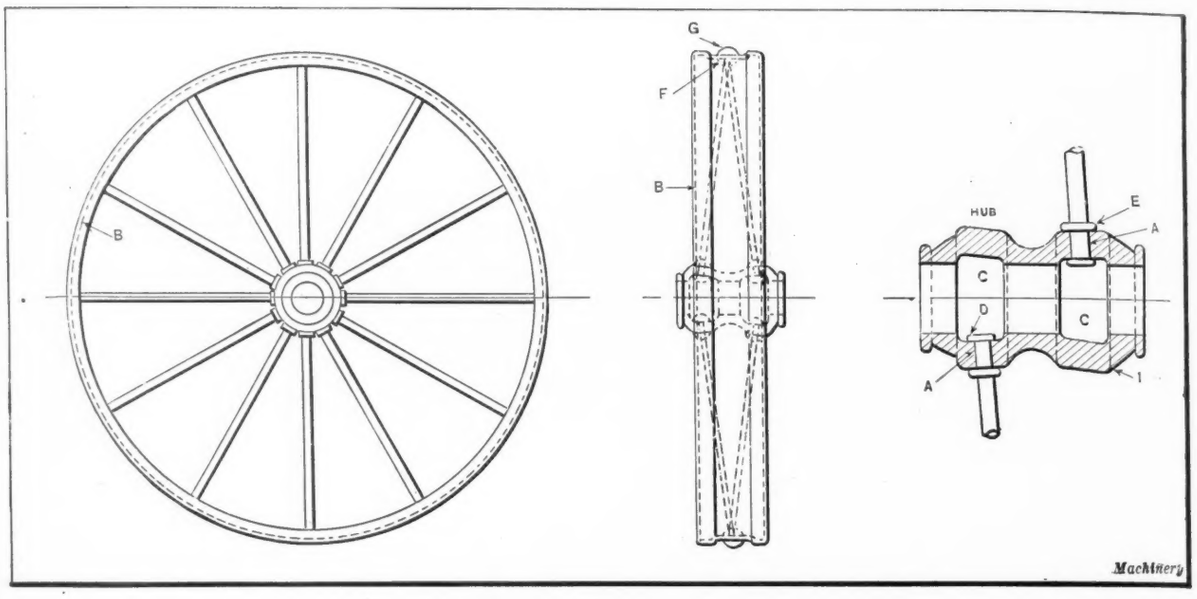


Fig. 7. Steel Wheel in which the Spokes are assembled by upsetting

In determining the length to which to cut the wheel spokes, the fact that there are to be four upsetting operations must be taken into consideration. For example, with 9/16-inch round spokes, the length of material required for each upset is ⅞ inch, and so a total extra length of 3½ inches is necessary. This allowance will permit the upsets to be 1 inch in diameter and ¼ inch thick. After cutting the spokes to length, the next operation is to upset a shoulder on the tire end of the spokes and taper this end, as shown at *A*, Fig. 8. The taper facilitates assembling the spoke into the tire and obtaining a tight fit in the punched tire hole.

The dies used in upsetting this shoulder are shown at *B*, the left-hand block being the stationary one. The plunger used in the operation is shown at *C*. From the drawing of the wheel shown in Fig. 7, it will be apparent that a straight spoke would project through the tire at an angle, and so it is necessary to compensate for this angularity at the time of upsetting the shoulder. This is accomplished by machining the plunger face *E*, Fig. 8, at an angle and machining recess *D* at right angles to this face. The plunger is then so set in the machine that it will scrape the end of the stock slightly and force it to the angle shown at *A*. It is essential, in upsetting the spokes, to avoid a sharp corner at the junction of the shoulder and the remainder of the stock. This is done by countersinking the ends of the recesses in the gripping dies and by slightly rounding the edge of hole *D* in the plunger. If this were not done, a fracture would start in the spokes just under the tire or beneath the shoulder when the wheel was placed in service, and would greatly shorten the life of the wheel. The holes in the tire are not countersunk; however, the slightly rounded shoulder of the spokes presses into the steel at the edge of the holes and produces the desired effect to a certain extent.

The life of the gripping dies used in this operation is greatly increased by taking advantage of the four sides of the blocks. Each pair of sides is clamped together with a thin metal strip between, and a hole is drilled to the same diameter as the spoke. With this filler strip removed, the dies will grip the stock firmly. After the drilling, the dies are hardened and drawn. The plunger is a piece of tool steel, forged with a shank in which a V-notch is cut to furnish a means of attaching to the machine. Recess *D* is tapered to an included angle of 3 degrees. The bottom of this recess is of the same diameter as the spoke stock so as to make the spoke slightly larger at the shoulder and thus provide a means of pressing the tire snugly on the spoke.

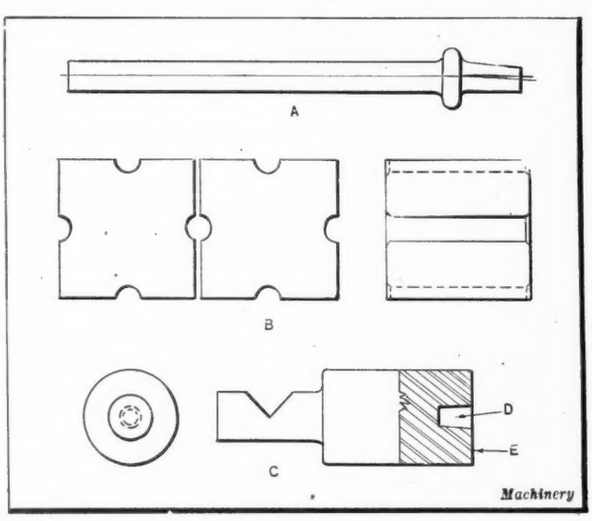


Fig. 8. Gripping Dies and Plunger used to produce Spoke A

Assuming that the spokes are in tension and that the ultimate tensile strength of the steel used is 80,000 pounds per square inch, the ultimate tensile strength of each spoke is about 19,880 pounds. The stresses on the upset portions at the outer end of the spoke tend to shear the end, and so the resistance against shear in these portions must be equal to the tensile strength of the spoke proper. Thus, assuming the ultimate shearing strength of the steel to be 50,000 pounds per square inch, the area of the upset metal must be about 0.400 square inch. The diameter of the outer upset portion should be sufficient to prevent it from being pulled through the hole in the tire.

* * *

The percentage of exports represented by manufactured goods, compared with our total exports, is constantly increasing. Half a century ago the United States was largely an exporter of raw materials. Today, while we continue to export a large volume of raw materials, manufactured goods represent the larger share of our exports. During the first eight months of 1924 manufactured goods formed 56 per cent of the total exports, as against 46 per cent in 1922, 45 per cent in 1910, 35 per cent in 1900, 21 per cent in 1890, and 15 per cent in 1880. In our own manufacturing, however, we are constantly using a larger amount of raw materials imported from abroad. The value of imported raw materials in 1900 amounted to $276,000,000, as compared with $1,200,000,000 in 1924.

The British Metal-working Industries

From MACHINERY's Special Correspondent

January 15, 1925

AT the beginning of this year it is possible to say that the hopes of improved business entertained by almost every class of mechanical manufacturer throughout three long years of depression bid fair to be realized. Employment in the engineering industries is improving rapidly; in the important area of Coventry the number of unemployed in the metal-working industries is practically nil.

The Machine Tool Industry

A year ago very few machine tool makers were receiving any but desultory orders, but the last twelve months have, with the exception of a few short lapses, shown continuous progress. Overseas markets for machine tools have kept pace with those for home requirements. Most machine tool makers in the Midlands report very satisfactory conditions, and in a few cases the pressure of work calls for over-time shifts. The demand is fairly general, but automatic screw machines, turret lathes, drilling machines, and milling machines maintain a substantial lead. Machine tools for railway car construction are in increasing demand, and works specializing on these products are filling up their order books to such an extent that continuous work is insured for many months to come.

The Scotch machine tool plants have been slower to feel the improvement in the industry, but have shown a more business-like aspect during the last few weeks. Glasgow and Johnstone works are moderately busy on heavy tools.

Overseas Trade in Machine Tools

November, for the fourth month in succession, showed an increase in the tonnage and value of machine tools exported; the total tonnage was 1108, with a value of £140,056. These figures represent a slight increase in tonnage, and a substantial increase in value from the corresponding October figures, which were 1087 and £122,500, respectively. The value per ton rose, therefore, from £113 in October to £126 in November. The general trend of exports since January, 1924, has been steadily upward, except for a depression in August that was compensated for by a substantial rise in July.

The imports in November fell from the October figures of 247 tons to 159 tons, the corresponding values being £44,336 and £37,726. In November, lathes were exported to the value of £49,500, that is, seven times the value of imported lathes. Exported presses in November showed a value of £14,700, or twice the value of imported presses. Exported drilling machines, grinding machines, and milling machines also showed a heavy preponderance over corresponding imports, but planers and shapers were exported and imported in about equal values.

India was the biggest customer for British machine tools in October, Australia being a good second. France, a long way behind, was third, with South Africa, New Zealand, and Portuguese West Africa following. America supplied the bulk of the imported machines during October, with Germany a poor second, the figures being approximately £28,500 and £11,279, respectively.

General Engineering Field

The extensive programs of the British Railways for 1925 will have a far-reaching effect throughout the engineering industry, and rolling stock builders, railway material shops, and the foundry trades are already participating in the resulting activities. The plans of the London & North Eastern Railway call for an expenditure of £6,000,000 during the present year. Some of the largest orders ever given for rolling stock by British railways have been placed.

The big electrical engineering concerns, such as Metropolitan Vickers Electrical Co., Ltd., Trafford Park, and the General Electric Co., Ltd., are busy in nearly all departments. There is a better demand for small electric motors. A contract of between £3,000,000 and £4,000,000 for the electrical equipment of the rolling stock required for the electrification of the suburban lines of the South African railways in the neighborhood of Cape Town has been awarded to the English Electric Co.

Gas engineering firms are busy as a result of recent orders for extensive plant additions in the leading gas works in the country. Like the machine tool industry, the textile machinery trade has been slow to benefit from the general improvement, but one or two recent orders of a substantial nature strike an encouraging note.

The Automobile Industry

In the automobile industry, the outlook is most promising. Most manufacturers are settling down to their 1925 programs, and the whole tendency of the trade is toward larger outputs. A feature of the situation is the gradual expansion in export trade. As to motorcycles and bicycles, these sections of industry appear altogether to have lost seasonal variations, and they are working today almost as busily as in the height of the summer season. The explanation is that the export trade is now of such proportions as to effectively bridge the in-between periods of the home trade. Several large concerns are busy with heavy schedules, and night shifts are general, but firms are behind with deliveries.

Shipbuilding

The output of shipbuilding continues to be favorable, and on the Clyde particularly a fair bulk of new orders has been received. These new orders have eased a somewhat unpromising outlook, although it is stated that prices have been cut down to an absolute minimum. Glasgow, however, still shows a greater percentage of unemployed in the engineering industry than other centers, and a much greater quantity of shipbuilding will have to be booked before the district can view the outlook with confidence. At Barrow, Vickers, Ltd., launched over 42,000 tons during 1924, as compared with 2183 in 1923, but very little in the way of new shipbuilding is to be seen.

The shipbuilding returns for the year show that, while the mercantile tonnage launched from the shipyards of Great Britain and Ireland last year was more than double the total for 1923, the tonnage on which work was started during the last two quarters showed a marked decline, as compared with the corresponding figures for the first two quarters of the year. The total gross tonnage launched in Great Britain and Ireland is shown to have amounted to 1,439,624 tons, the corresponding figure for 1923 being 645,651 tons.

Iron and Steel

In the iron and steel industries, the steadiest branch is that which is concerned with heavy steel. Other branches, however, including pig iron, show signs of improvement, and, as previously mentioned, are providing for a larger output in the new year. The best grades of tool steel are selling well, and some of the light forges are busy. Foreign competition in the special trades, either light or heavy, is now much less severe than it was during the early months of last year.

Current Editorial Comment

in the Machine-building and Kindred Industries

SALVAGING WASTE IN THE SHOP

In many machine shops more attention could be given profitably to preventing and minimizing the waste of materials of all kinds and to the reclamation of materials that for one reason or another cannot be used for their original purpose. In many plants it is assumed that there *must* be a certain amount of waste in materials due to faulty design or workmanship, or to inadequate inspection of incoming raw materials. The loss thus incurred is charged to overhead, and unless it becomes noticeably large, no particular effort is made to reduce it.

One large electrical manufacturing concern has organized a special department in charge of a salvaging engineer to prevent waste and to find uses for scrap material. By careful checking of the methods of designing blanking dies, for example, with reference to the width of the stock from which stampings are blanked, it is possible to effect considerable savings in the amount of sheet metal used. Similarly, by using upset forgings instead of bar stock, a large amount of metal may be saved in machining. Some cutting-off processes waste more material than others. Proper annealing of stock will save tool expense. In many other ways it is possible, by careful planning, to decrease manufacturing costs and avoid waste of materials.

In a large plant, it is worthwhile to make a study of converting apparently useless scrap into money. Several years ago the electrical manufacturer referred to made a careful study of the various kinds of non-ferrous scrap resulting from the operations in his plant. The quantities of each kind were noted, the amounts received from their sale were recorded, and a study made of the cost of reclaiming these metals directly by a reduction plant. It was found that this reclamation by the manufacturer himself could be made so profitably that now he not only reclaims all his own non-ferrous scrap metal, but buys scrap metal from other plants and reclaims it in his reduction plant. This is mentioned only as an example of how waste may be turned into profit when the volume is sufficient to warrant the installation of somewhat expensive equipment; but there are many cases where waste can be avoided by simply watching the design of the product and the manufacturing and machining operations, and preventing the use of more material in the process of manufacture than is absolutely necessary.

* * *

THE FOREMAN

The shop foreman has been called the "keyman" in recognition of his importance as a direct connecting link between employer and employe. As many ambitious machinists and toolmakers aspire to obtain positions as foremen, we will outline briefly the more important qualifications.

To begin with, a good foreman must have the respect of his men. Workmen, as a rule, admire a foreman who "knows his job"; but mechanical ability alone is not sufficient. A foreman must inspire confidence through good leadership and square dealing. A good foreman has enough backbone to be the boss whenever required, but he always avoids an unnecessary display of authority. The knock-down-and-drag-out type of foreman and the "mollycoddle" are equally useless in a modern industrial plant.

A competent foreman makes men feel that they work *with* him rather than *for* him. He appreciates commendable work and gives full credit for it, as well as for helpful suggestions. A good foreman is able to instruct his men, and does it when necessary, but in a modest way and without show of superior knowledge. He is on friendly terms with his men, but there is no back-slapping familiarity. He is tactful, sympathetic, firm for what he knows from experience to be right, a true friend to the man who honestly tries, and a terror to the out-and-out shirker. He has the knack of getting on with men, and they respect and admire him for his qualities as a man and his abilities as a workman. Loyalty to both the company and its employes is an essential trait of a really competent foreman.

The spirit that exists between the workmen and the management often depends largely upon the character and ability of the company's representative—the foreman. The foremen's clubs which now exist in various industrial centers are doing valuable work in promoting a better understanding of the possibilities and opportunities of good foremanship. The primary object of the Ohio Federation of Foremen's Clubs is "to help its members in the promotion of better foremanship by studying the needs and opportunities of industry, in order to make each individual foreman a power for good in his own organization and community." This excellent objective might well be adopted generally as a guiding principle by all leaders in the machine-building and other industries.

* * *

BETTER MACHINE TOOLS FOR SCHOOLS

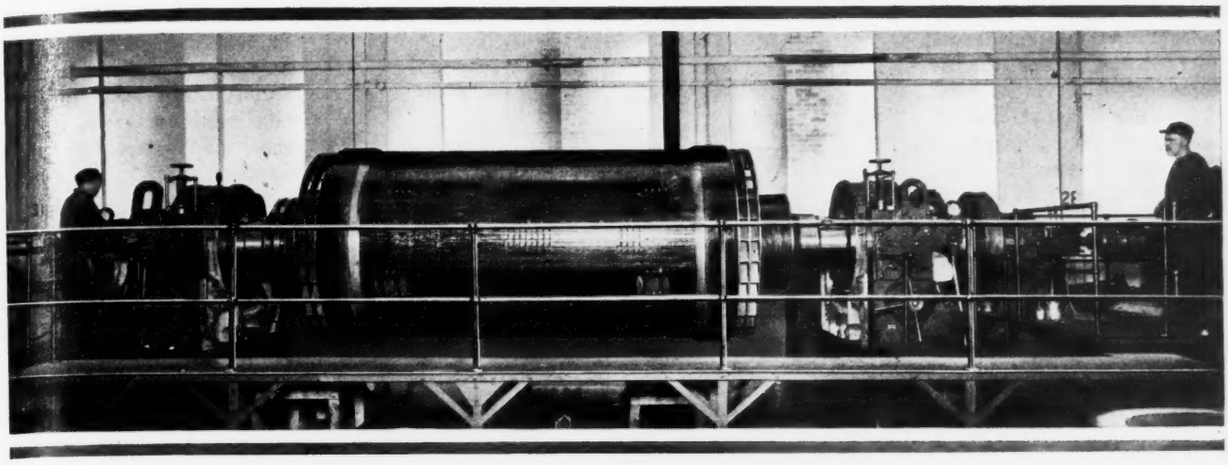
Manual training schools, trade schools, and the machine shops connected with technical and engineering colleges, as a rule have very limited appropriations at their disposal. As a result, the cheapest machine shop equipment, irrespective of quality, is often obtained for such institutions. The men in direct charge of the machine shops know well that it is not economical to buy inferior equipment because the price is low, but they are seldom able to convince those who control the appropriations of this fact.

Machine shop equipment for schools that are to train our future mechanics and engineers should not be bought on price—surely not on price only. If boys and young men are to get an accurate conception of the work for which they are fitting themselves, they should have good equipment in their training shops; and as good equipment will give lasting satisfaction and stand up longer, it is altogether the most economical.

There have been some notable exceptions to the objectionable practice referred to. One of the largest technical high schools in the country recently equipped a shop on a basis that enabled builders of the highest grade of productive machine tools to enter their bids; and while the order was placed with the lowest bidder of a given quality of machines, no effort was made to obtain a low price by sacrificing quality.

In justice to machine tool builders that have to some extent specialized in training school equipment, it should be said that they have brought out certain simplified machine tools particularly suited for school use that are cheaper in price than the regular production machines, but not inferior in quality—the lower price being due to such standardization of machines suitable for training purposes that they can be built in fairly large quantities.

The men in charge of training shops, who often work under great handicaps, should not be blamed for their inability to purchase the equipment needed; but should be helped by their school boards and by manufacturers to obtain machine tools that meet their requirements.



Rotative Balancing

A Simple Explanation of the Theory of Balancing, and a Description of Practical Balancing Methods

By RICHARD SODERBERG*, Motor Engineering Department, Westinghouse Electric & Mfg. Co., East Pittsburg, Pa.

THE development of practical methods for balancing the centrifugal forces in rotating bodies was accelerated by two advances of an epoch-making nature several years ago. The first and most important one was the application of the resonance phenomenon, and the second, the use of compensating weights. It seems that neither of these advances can be attributed to any one inventor. The first complete description of a balancing machine based on the resonance principle appears to be a treatise by F. Lawaczeck published in *Zeitschrift für das Gesamte Turbinenwesen*, (October 11, 20, and 30, and November 10, 20, and 30, 1911). The fundamental features were known long before, however. The method of using compensating weights was described by N. W. Akimoff in a paper on "Dynamic Balance" read before the American Society of Mechanical Engineers. (Trans. A. S. M. E. Vol. 38, 1916, page 367).

The use of compensating weights in rotative balancing has its direct parallel in the common scales. Temporary counterbalancing weights were very likely in use long before the introduction of the resonance principle. Later advances in the art have placed the balancing process on a rational production basis. The principle of balancing around pivot axes in the planes of the corrections, as employed in the balancing machine with a movable fulcrum and similar arrangements, is of great importance in this connection.

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The balancing problem in its simplest form can be stated as follows: A body (Fig. 1) is rotated in two bearings A and B. This rotation will be accompanied by centrifugal forces f in each mass element of the rotor. The centrifugal forces are all directed radially from the axis of rotation AB. This system of radial forces may be internally balanced, in which case the reactions upon the bearings A and B will be composed of the reactions due to gravity and eventual external forces; but this system of radial centrifugal forces is usually not balanced, and, therefore, the bearings are subjected to radial forces F_A and F_B, as well, rotating with the body. These rotating reactions are the two resultants of the entire system of centrifugal forces.

The ultimate effects of these reactions depend upon their magnitude and the elastic properties of the bearing supports. If these supports are perfectly rigid, the centrifugal forces can have no other effect than an infinitesimal bending of the rotor shaft. This bending may be of importance in many cases, but the consideration of this feature forms another chapter of the problem, namely the vibrations in flexible rotating bodies. It is not allied with the balancing problem, which must be considered from the point of view of a stiff rotor shaft.

Since the bearing supports are not, in general, perfectly rigid, the unbalanced system of centrifugal forces will manifest itself as deflections in the directions of minimum restraint. These deflections are of a periodic nature, the rate of reversal, or the frequency, being that of the rotation. The object of balancing the centrifugal forces in a rotating body is the elimination of these periodic deflections of the supports.

Since the resultant of the system of centrifugal forces can be considered as being two forces F_A and F_B in the

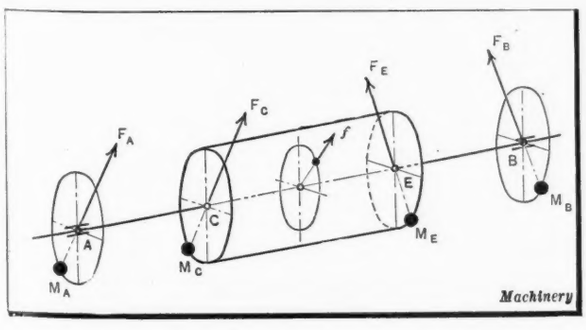

Fig. 1. Diagram indicating General Condition of Unbalance in a Rotating Body

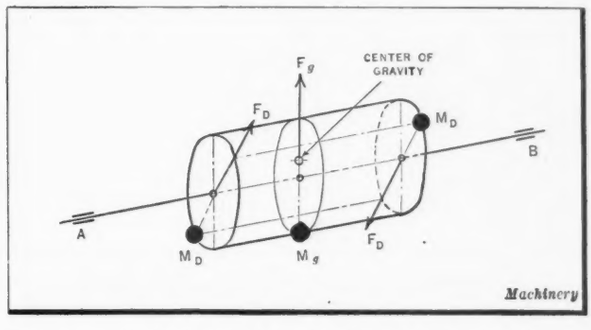

Fig. 2. Diagram indicating State of Static and Dynamic Unbalance in a Rotating Body

planes of the bearings, it is evident that this unbalanced part of the system can be counteracted by two masses M_A and M_B placed opposite the corresponding forces at a suitable radius. In most cases, it may not be possible to apply the corrections in the particular planes of the bearings, but it is evident at once that an equivalent effect may be obtained by placing the corrective masses in two other planes *C* and *E*. Naturally, the angular positions and the magnitude of these masses M_C and M_E will be different from those of M_A and M_B.

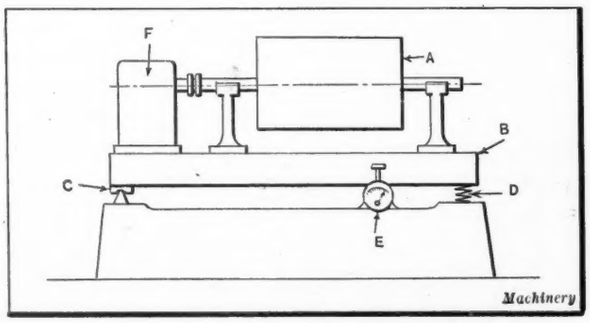

Fig. 3. Typical Mechanical System for Balancing Machines

We have established, therefore, that the general condition of unbalanced centrifugal forces can be corrected by two masses of suitable magnitude and location in two arbitrary transverse planes of the body. These two masses can be combined into one, provided they are located in the same longitudinal plane and on the same side of the axis. Excluding this special case, they form the most advantageous combination of weights which can counteract the reactions of the unbalanced system of centrifugal forces.

There are clearly an unlimited number of other methods by which the system can be balanced. The most important of these other methods is arrived at by resolving the system of centrifugal forces into its resultant force and resultant couple (Fig. 2). The former will be located at the center of gravity of the body, and the latter will act in a longitudinal plane through the axis. The resultant force is counteracted by a suitable mass M_z in the plane of the center of gravity, the resultant couple being counterbalanced by two suitable masses M_D of equal magnitude, located on opposite sides of the axis in the longitudinal plane of the couple. The application of the former is conventionally termed *static balance;* the application of the latter is termed *dynamic balance.* These names were derived from the practical methods of obtaining the balance. The static unbalance manifests itself without the creation of centrifugal forces by rotation, because the rotor, if placed on parallel rails, will automatically take the position of stability with the center of gravity lowest. The dynamic unbalance received its name from the process of dynamic balancing by rotation.

Early Development of the Balancing Machine

The existing methods of balancing are all based upon either one of the above treatments of the system of centrifugal forces and its resultants. Before the resonance principle was introduced, it was customary to apply the static correction first, and then the dynamic correction by cut and trial, for which purpose the rotor was mounted in its regular bearings and rotated at as high a speed as possible in order to magnify the vibratory deflections. In certain cases the entire unbalance was corrected in this manner.

The difficulties which at that time accompanied the balancing process were due to the fact that the constraint of the bearing support was disregarded. The location of the unbalance was obtained by marking the shaft, but the phase displacement between motion and unbalance was not understood by the operators and could not be taken into account. The seemingly erratic variation of this phase angle mystified the operators, and the most successful guesser was regarded as a man with a sixth sense. Since both bearing supports were moving simultaneously, the actual motion of the rotor was, in reality, exceedingly complicated. The problem became greatly simplified when someone conceived the idea of increasing the flexibility of the bearing supports and of attempting to balance one end of the rotor while locking the other end. This created the shop tool which at the present time is known as the balancing machine.

The Theory of Balancing—The Resonance Phenomenon

Let us consider an arrangement of the type shown in Fig. 3. An unbalanced rotating body *A* is mounted on a rigid bed *B*, which is supported on a knife-edge *C* at one end and on springs *D* at the other end. Assuming that the pedestals are stiff and that the bed is prevented from moving in all other directions except around its fulcrum axis, the effects of the unbalanced centrifugal forces will be an up and down oscillation. The rate of oscillation will be the rate of rotation. The magnitude of the deflection can be recorded on the indicator *E*. The most practical form of this indicator is a common dial gage, reading to 0.001 inch.

Now assume that the rotor is started and the speed of rotation raised by gradual steps, and at each new value the speed is maintained constant sufficiently long to stabilize the motion. For each speed we observe the maximum throw of the indicator needle. If corresponding values of speed of rotation n and maximum throw a are plotted in a curve, it will have the appearance of curve *A* in Fig. 4. The most important feature of this curve is the fact that the amplitude does not increase directly with the speed of rotation, although the magnitude of the centrifugal forces increases. Instead, the amplitude increases very rapidly up to a certain speed n_c and then falls off toward a low value for higher speeds. The particular speed n_c is denoted as the *critical speed* or the *resonance speed* of the system. The value of this speed depends upon the stiffness of the spring

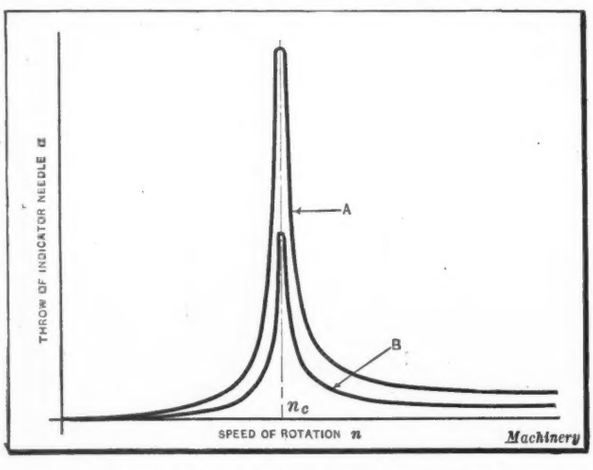

Fig. 4. Curves showing Relation between Speed of Rotation and Vibration

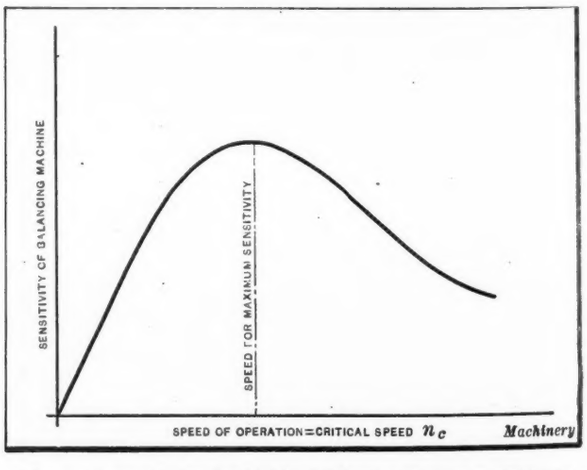

Fig. 5. Curve showing Sensitivity of Balancing Machine for Different Operating Speeds

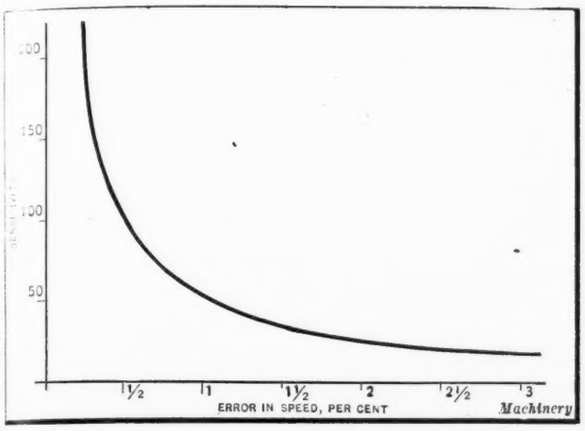

Fig. 6. Relation between Inaccuracy of Tuning and Sensitivity

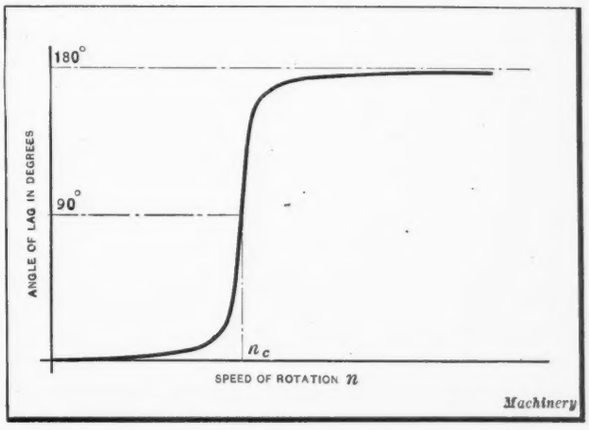

Fig. 7. Curve showing Relation between Angle of Lag and Speed

and the inertia of the moving mass. If the system is arranged properly, the deflection at the critical speed will be 100 to 200 times the deflection at a very high speed. This explains the very high sensitivity that is obtained by this arrangement.

The reason for this phenomenon is found in the fact that at the critical speed the effects of the unbalanced forces become cumulative. The oscillating motion of the system is an exchange of energy; the potential energy of the springs being changed into kinetic energy of the mass and vice versa. The critical speed corresponds to the *natural rate of exchange* of energy. At this speed all impulses from the centrifugal forces are converted into kinetic energy, that is, into motion of the vibrating table *B*, Fig. 3. As the amplitude increases, however, the losses due to friction and windage increase, so that the amplitude does not increase indefinitely. When the maximum amplitude is attained, the energy supplied by the centrifugal forces is dissipated by friction. This phenomenon of natural exchange of energy is called *resonance*. The value of the amplitude of motion at resonance depends upon the magnitude of the unbalance, the amount of friction, and the inertia of the system. If the unbalance were reduced to one half, the resonance curve would have the shape of curve *B* in Fig. 4.

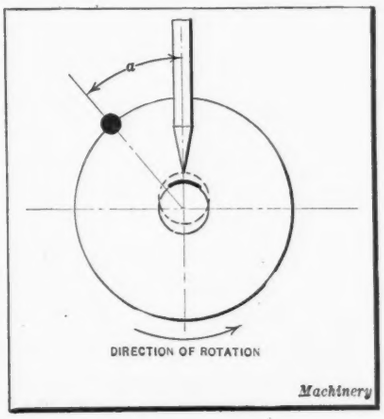

Fig. 8. Diagram showing Relative Position of Mark on Shaft and Unbalanced Section

The actual value of the resonance speed n_c does not influence the maximum amplitude to a very great extent. For example, if we increase the stiffness of the spring *D* in Fig. 3, the maximum motion will occur at a slightly higher speed, and the value of the new maximum amplitude will change slightly. If the springs were changed a great deal, it might result in an appreciable reduction of the maximum amplitude, or in other words, of the sensitivity of the balancing machine. Generally, there is a certain speed at which the sensitivity is greatest. This speed is usually very low, and it may be advantageous to place the resonance speed slightly above this theoretically best speed in order to simplify the operations. Fig. 5 shows an example of the variation of the sensitivity for different resonance combinations. By sensitivity is meant the ratio of amplitude at resonance to amplitude at a very high speed (see Fig. 4). The latter does not depend upon the springs but only upon the unbalance and the inertia of the system.

Another very important feature of the resonance condition is the close speed regulation that is required in order to obtain the maximum motion. It is evident from Fig. 4 that a very minute change of speed from n_c will result in an appreciable change of amplitude. This requirement of accuracy of tuning has been one of the difficulties in resonance balancing machines. Only recently has this condition been sufficiently appreciated. The ultimate effect of improper tuning is a reduction in the sensitivity. If we adhere to our previous definition of the sensitivity and plot the relation between error in speed and sensitivity, we

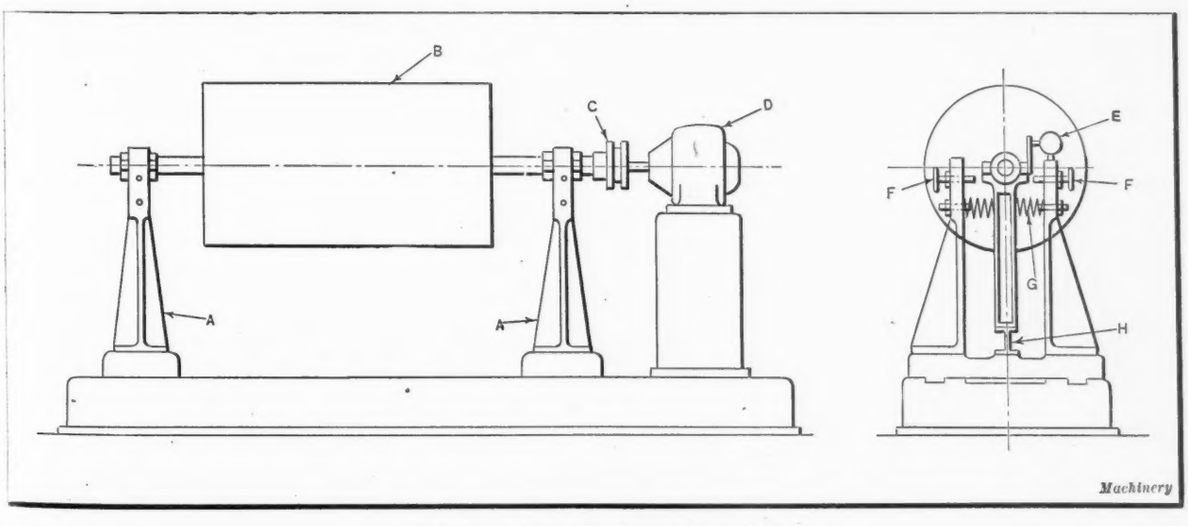

Fig. 9. Pedestal Type of Balancing Machine

obtain the curve shown in Fig. 6. It is evident from this curve that it is necessary to control the speed within ½ per cent in order to have a sensitivity of 100—a figure which has proved to be essential for accurate work.

A third and very interesting condition of the resonance motion is the relative angular position of the unbalance and the maximum motion. This is of importance in connection with the old method of locating the unbalance by marking the shaft of the rotor. Let us assume that the unbalance of the rotor in Fig. 3 consists of an individual mass in a certain plane. Fig. 8 is an end view of the rotor, with the position of this mass and the position of the corresponding mark of a pencil indicated, the latter approaching the shaft from above. In general the pencil mark will lag an angle *a* behind the unbalance. If we plot values of *a* to the corresponding speeds of rotation, we obtain the curve shown in Fig. 7.

At resonance the mark will lag behind the unbalance by 90 degrees. Below resonance the angle of lag will be less than 90 degrees; above resonance it will be greater than 90 degrees, approaching 180 degrees for very high speeds. It is important to note that the variation of the angle is very rapid in the neighborhood of resonance, so that we may expect to obtain erratic results at that speed. It can be shown that a certain error in speed will change the angle of lag by an amount proportional to the product of the speed variation and the sensitivity. Thus, if the sensitivity is 50 and the error in speed is ½ per cent, the angle of lag will change not less than 25 degrees. On the other hand, if we attempted to obtain a marking at a higher speed, the angle of lag would be more stable, but the amplitude of motion would be too small to give a distinct mark. This explains why the attempts to locate the unbalance by marking the shaft usually fail in balancing machines.

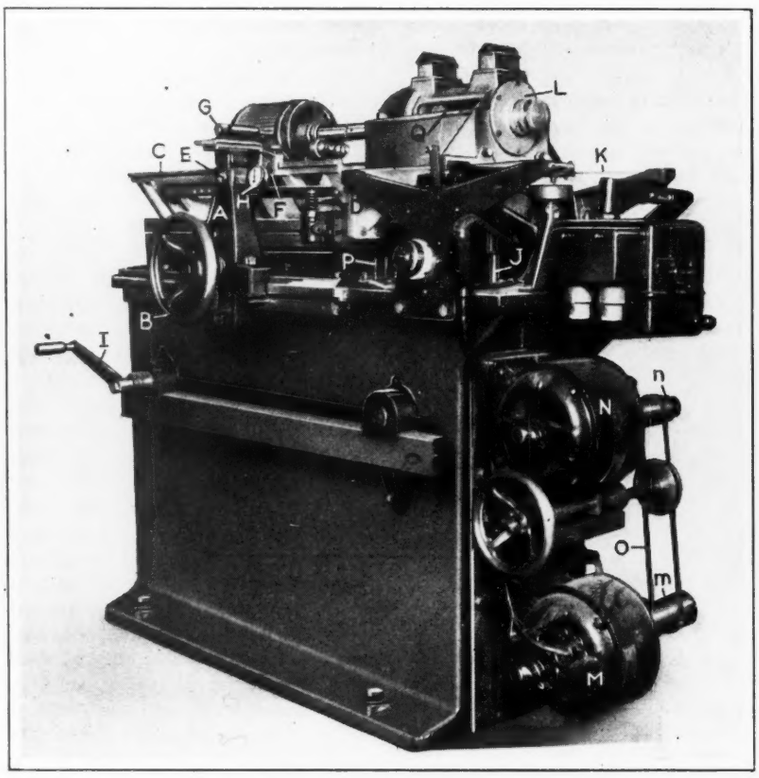

Fig. 10. Balancing Machine provided with Movable Fulcrum Bearing

The Static-dynamic Balancing Machine

The system illustrated in Fig. 3 will serve very well as an indicator of the unbalance in the rotor *A*. There is a distinct disadvantage, however, in the fact that the entire unbalance is effective, and the proper combination of two weights must be obtained simultaneously. This disadvantage is obviated by placing the fulcrum axis parallel to the axis of rotation, in which case only the static unbalance becomes effective and can be ascertained and corrected. By subsequently placing the fulcrum axis in the position shown in Fig. 3, the residuary dynamic couple can be determined and corrected. This is the principle of the type of balancing machines known as the static-dynamic balancing machines.

The operation of the machine is simplified by using a counterbalancing device *F*, consisting of an artificial unbalance in the driving mechanism, which can be changed in magnitude and location to compensate for the unknown unbalance of the rotor. This is, evidently, a direct application of the principles of all weighing devices.

The fundamental disadvantage of this system lies in the fact that the static unbalance must be corrected before the dynamic unbalance can be determined. This results in slow operation and, what is more important, inaccurate results. The latter condition is due to the fact that eventual residuary static unbalance will affect and distort the readings for the dynamic unbalance. It is especially serious if the static error is located at a considerable distance from the pivot axis.

The Pedestal Balancing Machine

The pedestal balancing machine can be regarded as the prototype of all balancing machines. It is a direct outgrowth of the original method of balancing in ordinary bearings. Fig. 9 shows the arrangement, which consists of flexible pedestals *A* that support the rotor *B* which is to be balanced, and a flexible coupling *C*, a driving motor *D*, indicator *E*, stop *F* for locking the pedestals, springs *G*, and the elastic connection *H*. In the heading illustration is shown a large machine of this type used by the Westinghouse Electric & Mfg. Co.

The fundamental feature of the arrangement consists in providing flexible bearing pedestals, so that the sensitivity can be magnified by resonance. If one pedestal is locked while the other is free to vibrate, the entire unbalance will be effective. These vibrations can be eliminated by applying a weight at the end farthest from the fixed pedestal. When the pedestals are reversed, the vibrations are again eliminated by applying a suitable weight at the other end. It is evident, however, that by the addition of this weight the equilibrium for the first end will be distorted. This can be corrected by distributing the weights applied in the second operation in such a manner that the equilibrium with respect to the first end is maintained. Another method is to apply the second weight directly and repeat the balancing operation two or more times. In most cases the result will improve the balance. Naturally, the latter method is slower.

In the arrangement shown in the heading illustration, the rotor is driven through a magnetic coupling. The actual balancing is performed while the rotor coasts through the resonance speed, the coupling being disengaged. The arrangement of the pedestals is slightly different from that indicated in Fig. 9 in that the flexible member, corresponding to *H* in Fig. 9, is under tension instead of compression.

Balancing Machine with a Movable Fulcrum

While the pedestal balancing machine has the advantage of being adaptable for very large rotors, it has the disadvantage, in common with the static-dynamic machines, that

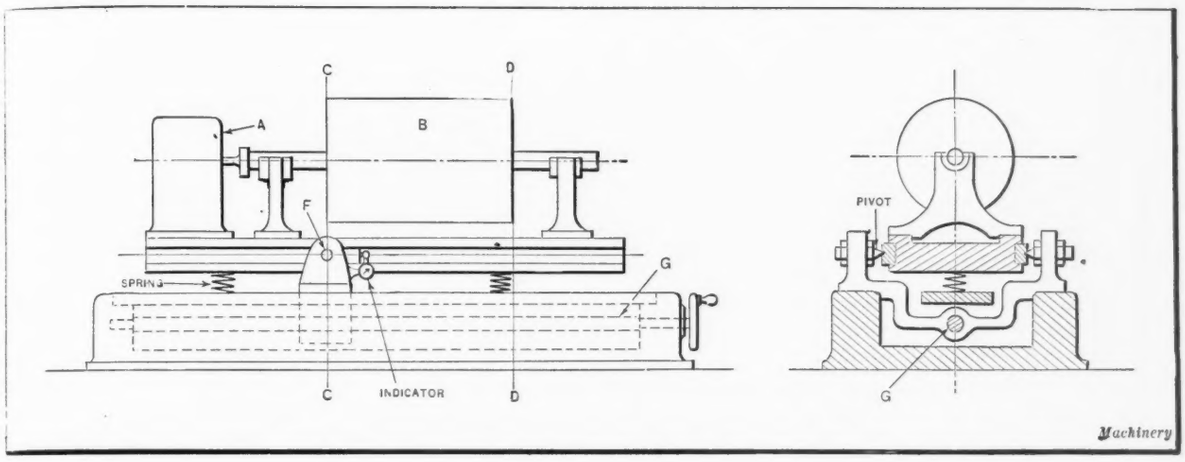

Fig. 11. Diagrammatic View of Balancing Machine with Movable Fulcrum

the operation is slow and the number of correction weights required is always three or more. Evidently the latter disadvantage would be eliminated if the bearings or the pivoting points could be placed in the transverse planes where corrections are to be made. This condition is accomplished in the balancing machine with the movable fulcrum shown in Fig. 11. The arrangement is similar to that of the static-dynamic machines, except that the pivot axis can be moved to any location with respect to the rotor.

The balancing performance is self-evident. Two transverse planes which are most convenient for receiving weights are selected, and the pivot axis is moved into one of these planes, such as *C–C*, for example. The balancing operation around this plane determines the location and magnitude of the weight to be applied in the other plane *D–D*. The correction weights can be determined by cut and trial or by a compensating mechanism similar to the one used on the static-dynamic machines. It is not necessary to apply the first weight before the second operation is performed, since, being located in the pivot plane, it would be ineffective. This second operation determines the weight to be applied in the first fulcrum plane.

Advantages of Movable Fulcrum Balancing Machine

The following are the most important advantages of the balancing machine with a movable fulcrum:

1. The condition of unbalance is corrected by a minimum number or amount of correction weights. The number of places where corrections are made is two, unless the design of the rotor is such that a weight cannot be applied at the point of indication.
2. The entire balancing operation can be performed without permanent application of balancing weights. This permits using the balancing machine to its full capacity; the unbalance can be indicated on the machine and applied elsewhere.
3. The accuracy of the result is uniform and equal to that of each individual operation.

Problems Met with in Developing the Balancing Machine

The development of this type of balancing machine involved a number of interesting problems of which the following is an example:

It is evident from our previous discussion of the resonance phenomenon that each fulcrum location will produce a system of different vibration properties, because the inertia and the effect of the springs will vary. Therefore, it is to be expected that each fulcrum location will give a different critical speed. This difficulty was overcome by arranging the spring suspension in such a manner that a fulcrum location having a greater moment of inertia also has a greater spring resistance. The fundamental principle of this arrangement is best understood by considering the diagrammatic arrangement in Fig. 12. Here the vibrating bed is represented by member *A*. It is assumed to have a mass *M*, including the bed proper, the rotor, the driving arrangement, etc. This member is supported by two springs *B* and *C* and restrained to oscillate around different axes in the fulcrum plane *F–F* at right angles to the plane of the paper.

Let us assume that the center of gravity of the vibrating system is located at *O*. When the fulcrum axis is in the corresponding transverse plane *P–Q*, the moment of inertia is at a minimum. Since the natural frequency of vibration depends upon the ratio of spring moment to moment of inertia, the former should also be at a minimum when the fulcrum axis is in the plane *P–Q*. This is obtained by placing the spring members *B* and *C* (assumed to be equal) symmetrically with reference to the plane *P–Q*. Now, if the fulcrum is moved into some other plane, as P_1–Q_1 for example, the moment of inertia is increased. It is necessary, therefore, that the moment of the springs receive a corresponding increase, so that the ratio may remain constant. This occurs if the distance between the spring members is twice the radius of gyration *Q* of the vibrating system with reference to the central fulcrum axis. Then the period of vibration will be the same for all fulcrum axes.

The truth of this is evident if we replace the vibrating system by two concentrated masses $M \div 2$. If these masses are placed centrally with respect to the center of gravity and at a distance $2f$ equal to twice the radius of gyration with respect to the central axis, they form a perfect dynamical equivalent to the real system. These imaginary masses will fall at the spring members. Oscillations of the system around any fulcrum axis will represent vertical oscillations of these masses. It is evident from this that the natural frequency of the oscillations must be independent of the location of the fulcrum axis. The same results can be obtained by replacing the two spring members *B* and *C* by one supporting spring in the center of gravity and one torsion spring at the pivot axis. The latter takes care of the minimum moment of inertia, while the former compensates for the increase of inertia at various pivot axes.

This feature of a constant resonance speed, or speed of operation, for all fulcrum locations has proved to be very valuable in balancing machines for large output.

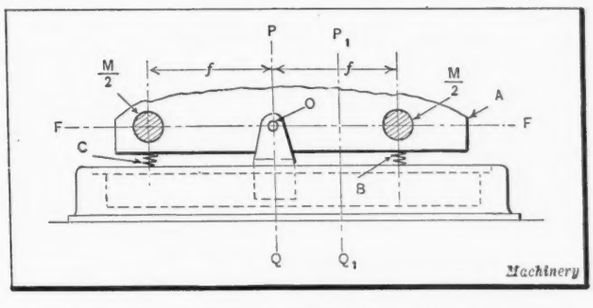

Fig. 12. Diagram showing Requirements for Constant Natural Frequency of Vibrations

It relieves the operator of frequent tuning for proper speed. Naturally, it necessitates adjustment for each type of rotor to be balanced. It is not necessary, however, in cases where only one or two rotors of the same type are to be balanced.

Construction of Balancing Machine

In Fig. 10 is shown a balancing machine of the movable fulcrum type. The fulcrum member is shown at *A;* its motion is produced by the handwheel *B* operating gears on a rack. The weight of the vibrating table *C* is carried by a pair of coil springs *D*, of which only one is visible. These coil springs are located in the transverse plane of the center of gravity and form the variable part of the spring element. The constant part of the spring elements is produced by the pivot members *E*, which consist of short torsion rods. The visible end of the pivot member is fastened to the fulcrum support *A;* the other end is fastened to a block *F*, which fits into the guide on the vibrating table; a center-punch *G* marks the location of the fulcrum plane with reference to the rotor, and at the same time indicates the place of addition or removal of weight. The motion is indicated by the dial gage *H*, attached to the fulcrum member. The crank *I* operates four members *J* which form solid supports for the vibrating table when the machine is not in use. The bed is restrained from motion in the horizontal direction by the flexible straps *K*.

The driving mechanism consists of a three-phase squirrel cage motor mounted in the head *L* of the vibrating table. This motor is fed by current from the stationary motor *M*, which is an induction motor with a wound secondary. A squirrel cage motor *N* rotates this secondary at predetermined speeds, thereby regulating the frequency and the voltage of the current supplied to the driving motor. The speed variation is obtained by moving the belt *O* on the cone pulleys *n* and *m*. Fig. 13 is a diagram of this driving arrangement. It is seen that the generator *M* is equivalent to a transformer having a rotatable secondary. The speed of rotation of this secondary is variable, but each setting gives an inherently constant speed, on account of the constant speed characteristic of the prime mover *N*. Naturally, the speed of the driving motor in the head *L*, Fig. 10, varies somewhat with variations of the load, but the arrangement is dimensioned to operate very nearly at its synchronous or no-load speed.

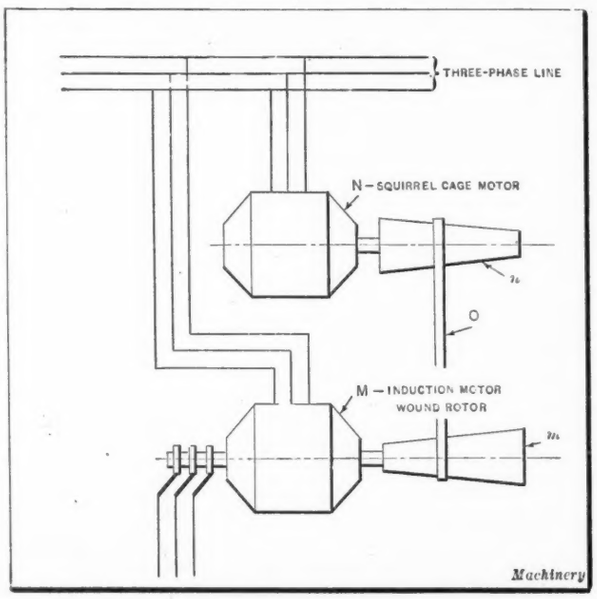

Fig. 13. Arrangement of Motor Drive on Machine shown in Fig. 10

Before this driving mechanism was introduced, a series of tests was made with a shunt-wound direct-current motor regulated by a rheostat in the field circuit. It was found, however, that the sensitivity of the balancing machine was increased nearly 100 per cent when this motor was replaced by the present drive. This illustrates the importance of close speed regulation.

In addition to the driving motor, the head *L* contains a compensating mechanism, consisting of eccentric weights which can be varied at will by means of electromagnetic relays, operated from a stationary switch *P*. This enables the compensating weights to be adjusted without disturbing the vibrations of the table. For each fulcrum location this artificial unbalance is adjusted so that it counteracts the effect of the unknown unbalance in the rotor. A scale *Q* indicates the amount and location of the result. This scale is arranged so that the center-punch *G* indicates the spot at which material should be added or removed.

Operation of Balancing Machine

The operation of the machine is as follows: After the rotor is mounted in bearings on the vibrating table, the fulcrum member *A* is moved so that the center-punch *G* falls in one of the two planes of the rotor where weight will be added or removed. The rotor is started and the speed adjusted for resonance. The reading on the dial gage gives an approximate indication of the magnitude of the unbalance, which serves as a guide for the subsequent adjustment of the compensating device. Then the artificial unbalance in this device is varied and rotated until the vibrations cease. The fulcrum is next moved into the other balancing plane, and the result of the first operation is marked on the rotor body. This performance is repeated for the new location of the fulcrum, and the second operation gives the correction in the first balancing plane.

In actual production work, the permanent corrections should be made after the rotor is taken out of the balancing machine. If a very large amount of correction is required, it may be necessary to check the result, but ordinarily no such check is needed. The balancing operation is usually performed in from five to ten minutes.

The accuracy of the balancing result is illustrated by the following figures: On a rotor weighing 150 pounds (maximum rating for the described unit), it is possible to obtain a distinct indication of 1 ounce-(inch)^2 unbalance. If a weight is added or removed at a 4-inch radius, and the horizontal distance between the balancing planes is 8 inches, this corresponds to a correction of 1/32 ounce, or approximately 1/75,000 of the weight of the rotor. The ordinary routine balance for this size of rotors requires only about one-third of this accuracy.

The introduction of this type of balancing machine in the manufacture of electrical machinery brought about a realization of the necessity of providing all rotors with suitable means for the application of the correction weights. It also established definite requirements upon these means. Unfortunately, some of the older types of motors cannot be changed to suit these new requirements. Frequently the changes involve changes of the motor housings as well as the rotors, so that the improved rotors would not suit the old housings. All new designs, however, are being arranged to meet the new requirements, so that their balancing will be a commercial possibility.

* * *

Standard invoice, purchase order, and inquiry forms recommended for use in all branches of American industry and commerce, were adopted by a national conference held under the auspices of the Division of Simplified Practice, Department of Commerce, at Washington, on January 14. Forty-five organizations were represented at this conference, including producers, distributors, and consumers, as well as wholesalers and retailers in leading commercial fields. Copies of the standard invoice, inquiry, and purchase order forms, as adopted by the conference, may be obtained, upon application, from the Division of Simplified Practice, Department of Commerce, Washington, D. C., or from the National Association of Purchasing Agents, Woolworth Building, New York City.

Cutting Cast-iron and Copper Alloys by the Electric Arc Process

By A. G. BISSELL, General Engineer, Westinghouse Electric & Mfg. Co., East Pittsburg, Pa.

A. G. Bissell

MOST salvage and scrap yards are confronted with the problem of reducing cast-iron and copper-alloy scrap to charging box size. The use of the drop ball is effective on some cast-iron pieces, but there are many castings, and especially those made of the copper alloys, that cannot be broken by this method. To heat these alloy castings until they reach the brittle stage and then drop them, involves considerable expense and uncomfortable labor. However, by utilizing the heat of an electric arc concentrated at the tip of a graphite electrode, cast iron, copper alloys, and corroded steel can be cut easily and at a low cost. Not only is the electric arc useful in cutting up scrap, but it may also be used in production work. It has been used to cut shapes from heavy brass plates that heretofore were cut mechanically with an expenditure of much time and labor.

By using the electric arc, sufficient heat may be concentrated at a point to melt, oxidize, or volatilize the metal involved and make a cut. In the case of cast iron, the action is mostly melting and the molten metal must be run out of the cut, but in the case of copper alloys, the action is melting, oxidation, and volatilization. In cutting cast iron, the fumes and smoke are much less than in cutting a copper alloy, an operation of the latter class being illustrated in Fig. 1. It was found, in cutting a cast-iron propeller, that an arc of 1 or 2 inches in length was required, using approximately 700 amperes. To cut copper alloys, a very close arc is used with about 900 amperes. With a close arc, the metal is volatilized and melted to make a neat, clean cut, while when a long arc is employed, only melting takes place, and consequently, much slower progress is made.

A. G. BISSELL, the author of this article, is an electric arc welding specialist for the Westinghouse Electric & Mfg. Co. His experience in arc welding has been wide and varied, and has won him a reputation as an authority on this subject. Mr. Bissell was born in LeRoy, N. Y., on August 9, 1890, and received his early education in the LeRoy High School and in the Tacoma, Washington, High School. He was graduated from the University of Washington in 1915 with the degree of Bachelor of Science in Chemical Engineering, and five years later was awarded a degree of Chemical Engineer.

Prior to entering the employ of the Westinghouse Electric & Mfg. Co., almost two years ago, Mr. Bissell was for two years chemical engineer for the Pacific Products Co. at its Port Townsend, Wash., plant, where he was engaged in supervision and control in the manufacture of fish fertilizers and fish oils, and for five years in the United States Navy Yard, Puget Sound, Washington, where he served as assistant chemist, metallurgist, engineer in charge of investigation and development of electric arc welding, and supervisor of the electric arc welding department.

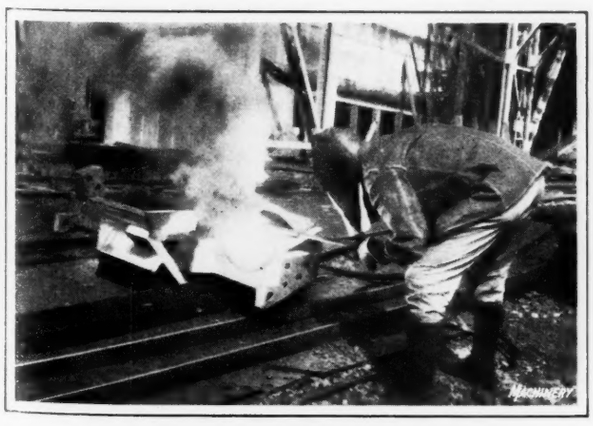

Fig. 1. Smoke produced in cutting a Copper Alloy Casting

The electrode used for this work is a 1-inch graphite rod, 8 inches long, which is tapered for a distance of 7 inches to a ¼-inch point. It is necessary to have the electrode this shape in order to maintain the arc at the very tip. Much better speed can be made by using the tapered electrode than by using a blunt-end electrode. The method of holding the electrode is shown in Fig. 2, from which it will be seen that clips which fit into a tubular handle hold the electrode in their grip. It has been found that if the end of the electrode that fits into the clips is spray-coated with copper, the electrode will not burn the clips or become loose by being reduced in size through oxidation. The casting here shown was made of brass and was too large to be received by a melting furnace. The operator, in a short period of time, cut it into sections small enough to be fed into the furnace. Before this cutting process was used, a brass ring, about 6 feet in diameter and 6 by 8 inches in cross-section, that had been miscast, was cut into scrap in the machine shop at a cost of nearly $200. With the electric arc cutting process, the same job is done for about $10.

Fig. 2. Using a Long Tapered Graphite Electrode in Electric Arc Cutting

Time and Power Consumed

Fig. 3 shows cuts made in a cast-iron propeller. The tip of the blade, measuring two feet across and having a maximum thickness of 1¼ inches, was cut off in 6.7 minutes with 750-ampere current. Fig. 4 shows a cut made in a bronze casting having a composition of 88 per cent copper, 10 per cent tin, and 2 per cent zinc. At the point of the cut, the web was 1½ inches thick. A cut one foot long was made in five minutes with 900-ampere current. It was about ⅞ inch wide and quite smooth. A 3- by 7-inch section of

the same casting, was cut in 9.2 minutes with a 950-ampere current. The increased rate in this case was due to the increased thickness, which necessitated working from two sides.

Other Applications

The electric arc may also be used successfully in removing risers, fins, and braces on copper alloy castings, and very good results have been obtained by using the process to rough out shapes from heavy brass plates. On the lighter-weight materials, it has been found that the heat has no detrimental effect on the metal structure to any appreciable depth. For instance, in cutting a riser 4 inches in diameter with 700-ampere current, it was found that the structure of the metal was affected to a depth of 0.7 inch, of which only from 0.125 to 0.25 inch was left in an undesirable condition. Allowance may be made for removing this amount of metal in the finish-machining. The process is especially useful in large manufacturing plants, shipyards, foundries, and smelters. Scrap yards find the process helpful in reducing steel scrap that is heavily coated with paint and rust, and smelters and foundries find it useful in melting out "frozen" tap holes.

The equipment suitable for supplying the electrical energy for this class of work consists of one or more motor-generator sets in connection with control equipment for regulating the arc current. A typical installation comprises four 1000-ampere motor-generator sets that are used to supply the energy for six operators using 700- to 800-ampere current each.

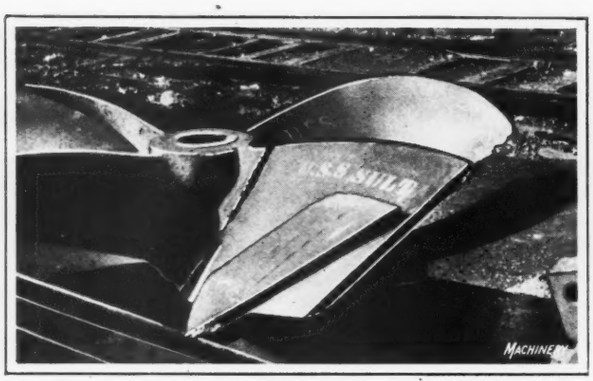

Fig. 3. Cast-iron Propeller cut by Electric Arc Cutting Process

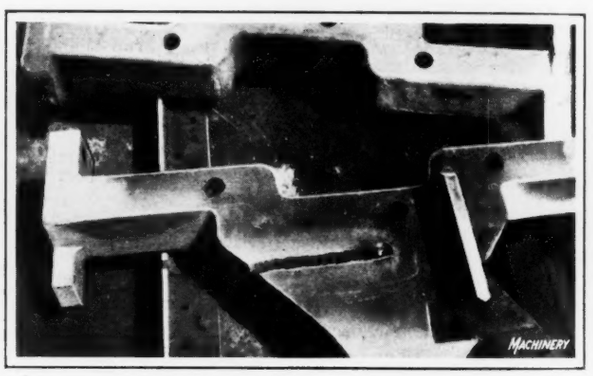

Fig. 4. Bronze Casting cut by using the Electric Arc

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GROUND HOBS FOR THREAD HOBBING

By L. K. GOSS, Commercial Tool Co., Cleveland, Ohio

Thread hobs that are not ground cannot be supplied to produce work within the tolerances of the Class 3 fit of the new National or American screw thread standards. Until within the last few months ground thread hobs could not be obtained at a commercial price, and formed hobs were therefore universally employed. Ground hobs can now be obtained from several sources which are guaranteed to be accurate on the pitch within 0.0001 inch and on the angle within 15 minutes per half angle. Formed hobs cannot be supplied that are guaranteed to be accurate on the pitch within 0.002 inch, and it is difficult to obtain any guarantee regarding the accuracy of the angle, because the teeth of the hob are distorted greatly in hardening. Examination of a considerable number of hobs showed the average angle error to be greater than 1 degree 30 minutes.

It may be mentioned that thread hobs do not have any lead, the feeding of the work past the hob being provided for by the lead-screw of the thread milling machine. Whatever error is in the lead-screw may thus be added to the pitch error of the hobs in determining the resulting lead error of the product. In addition to imparting lead errors to the product, pitch errors in the thread hob often produce unexpected defects in the form of the thread, making the thread either too thin and low or too thick and high. In either case the result is equally bad.

Copies of the dimensions and tolerances of the American standard screw threads, which may be obtained from the American Society of Mechanical Engineers, 29 W. 39th St., New York City, give the tolerances for the Class 3 fit on page 13. The cumulative pitch diameter tolerance for a 12-pitch thread is given here as 0.004 inch. The permissible lead error specified for this pitch is 0.0012 inch per length of engagement, the length of engagement being equivalent to the thickness of the nut.

If the lead error is at its greatest allowable amount, only one-half the allowable cumulative pitch diameter tolerance remains. The permissible error per one-half angle for this pitch is specified as 55 minutes, and if the error reaches this amount the other half of the cumulative pitch diameter tolerance will be used up. If both errors of lead and angle reach their greatest allowable values, it will be necessary to hold the calipered pitch diameter to zero in order to come within the specified tolerances. On the other hand, if the error in lead or angle of the hob is zero, it will be permissible to vary the calipered pitch diameter by practically the whole cumulative pitch diameter tolerance of 0.004 inch.

From an examination of the specifications for the closest obtainable guarantees for formed thread hobs it is apparent that they cannot be used to obtain the required fit. By using ground thread hobs the machine operator will have the advantage of greater tolerances on the calipered pitch diameter, which will result in increasing production. The question naturally arises as to how passable results were obtained before ground thread hobs became available. The answer to this question is that the pitch diameter of the hole was enlarged so that the imperfect screws produced by the unground hobs could be used. In the experience of the company with which the writer is connected, in supplying thread hobs and thread gages to the trade, enough cases where over-sized taps were ordered have been noted to indicate without a doubt that this method has been generally employed.

A grea many manufacturers are still without means for making accurate measurements of the lead or pitch, and a greater number have no means for measuring the angle of the thread. Equipment for making these measurements can now be obtained at so low a cost that there does not seem to be any good reason why the pitch and angle of the thread should not be examined as carefully as the pitch diameter is calipered, particularly in view of the fact that both the pitch and the angle are more important than the diameter. Obviously, results in obtaining greater accuracy can be obtained more quickly by inspecting for errors in pitch and thread angle and correcting the errors in these elements.

* * *

Exports of machinery from Germany, instead of improving in 1924, showed decided reductions. The figures for 1924 show a decline of about 15 per cent as compared with those for 1923.

Notes and Comment on Engineering Topics

It is estimated that the potential water power of Canada amounts to 18,250,000 horsepower, of which 3,225,000 horsepower is already developed. Of the developed horsepower over 2,400,000 is used in central station plants. The major portion of the electrical machinery and equipment is built in Canada, the country having a well developed electrical manufacturing industry; many of the plants are branch factories of American electrical manufacturers, but a few are operated by British builders of electrical equipment.

The possibilities of the coining type of press as a means of speeding up the production of automobile parts has recently aroused widespread interest among production engineers. It has been shown that forged arms, levers, and similar parts having surfaces or bosses that would ordinarily require machining can be squeezed to size in a coining press with the same degree of accuracy as is accomplished by the removal of the surplus stock in cutting operations. Records of carefully made tests tend to show that no difference in the molecular constituency of the parts results from the squeezing operation, and it is very likely that the new method will become quite generally used.

It is of considerable interest to note that the automobile industry has become one of the most important freight revenue producers for the railroads, even though it may have deprived the railroads of some local passenger traffic. Automobiles, it is stated, pay the highest rate per ton mile of any railroad freight traffic, and whereas wheat in the past has been considered as the most important of the railroads' freight business, the automotive industry last year contributed to the railroads' revenue 50 per cent more than wheat. This fact is of considerable interest in connection with the statement often heard that the automobile ruins the railroad business.

A high-pressure power plant consisting of a boiler and turbine designed to operate at a maximum steam pressure of 1200 pounds per square inch has been installed at the Weymouth power station of the Edison Electric Illuminating Co. of Boston. The high-pressure boiler and high-pressure turbine are operated together as a unit. The boiler generates the steam and superheats it to 700 degrees F., after which it is delivered to the turbine. From the turbine the exhaust at 360 pounds pressure returns to the boiler, where its temperature is again raised and the steam is then delivered to the main steam header for use in the normal pressure (350 pounds) turbo-generators.

Sand-blasting of boiler tubes is an established thing, but sand-blasting of turbine blades seems to be an entirely new practice. At the St. Louis pumping station, where steam turbines are used to drive centrifugal pumps, it was found that the efficiency of the units had fallen 25 per cent from the initial and guaranteed figures, according to the *Compressed Air Magazine*. Investigation revealed that the first five rows of turbine blades were almost completely closed with sediment. After the replacement of a few rows, the entire blading surface was given a thorough sand-blasting. This effectually removed all the scale; and, upon the resumption of service, the original steam consumption guarantees were equaled.

For many years there has been a widespread appreciation of the fact that locomotive draft, as ordinarily produced by exhausting the steam through a nozzle, is obtained at an excessive expenditure of power, and that a more effective means of producing draft offers one of the best means for increasing locomotive efficiency. Many devices have been introduced during the last ten years, both in this country and abroad, all of these methods including a small fan or blower driven by a steam turbine for producing the draft. In some cases, the turbine is supplied with live steam, and in others, with exhaust steam from the locomotive cylinders.

Extensive work in the electrification of railways is going on in Switzerland. Two factors have contributed to accelerating this work—very high coal prices prevailing toward the end and immediately after the war, and the large amount of unemployment in Switzerland, which made it advisable to undertake public works as emergency enterprises. The waterfalls of Switzerland now will furnish the power, and a large hydro-electric power plant system will make it possible to supply the needed electric current. One advantage gained by the electric locomotive, of especial value in Switzerland, is the elimination of smoke, a feature of great importance in a mountain region with such a large number of tunnels and heavy passenger traffic.

A Dutch inventor, Alexander Holle, has been at work in England for a number of years attempting to produce a wing for airplanes that will give a greater lift in comparison with the area than the wings now used. He has at last succeeded in constructing a wing called the "Alula" which meets these requirements. The new wing was recently demonstrated at the Northolt Airdrome in London. It was fitted to a Martinsyde "Semi-quaver" machine, equipped with a Hispano-Suiza engine of 300 horsepower, which was flown side by side with a Bristol "Fighter" having the normal type of wings. The Martinsyde, with the new wing, got off the ground very quickly, went up at a sharp angle, and reached a height of 3000 feet in 72 seconds. It attained a maximum speed of 180 miles an hour. The wing is shaped like the spread wings of a sea gull. It is made of mahogany planking and has no struts. Although the aim in designing the new wing was to obtain increased lift, greater speed has also been obtained.

What is said to be the widest rolling steel door ever made has recently been completed by the Cornell Iron Works, Inc., New York City, for the Kirkman & Son Building in Brooklyn, N. Y. This door is 45 feet wide and 17 feet high, and covers the railroad entrance to the plant. It weighs 2 tons, and is operated up and down by a 7½-horsepower motor through a train of spur gears, although only 3 horsepower is required to raise or lower the door, due to the action of twelve heavy helical counterbalancing springs enclosed in the door shaft. This shaft, when operated by the motor, makes six revolutions per minute, raising or lowering the door in thirty seconds. The motor is controlled by a set of push-buttons on each side, and the door may be stopped in any position. At the top and bottom of its travel, it is automatically stopped by a double set of limit switches. The rolling door coils entirely overhead, so that it is entirely enclosed in a semicircular sheet steel box or hood 26 inches in diameter. For emergency operation, a sprocket and hand chain is provided.

ASBESTOS

Asbestos is a fibrous mineral which is non-combustible and which, therefore, has many uses in the industries for fire protective purposes. The composition of asbestos varies somewhat according to the source from which it is obtained. Analysis made of various grades indicate that it contains about 40 per cent of silica, from 42 to 43 per cent of magnesia, from 1 to 3 per cent of ferrous oxide, from 1 to 2 per cent of alumina, and from 13 to 14 per cent of water. Asbestos was formerly a rare curiosity, but now it is applied to a great variety of uses in industrial arts, and these applications are constantly increasing. Its value in the industries depends not only upon its property of withstanding a high temperature, but also upon its low thermal conductivity, making it an excellent heat-insulating material for boilers and steam pipes. It also partially resists the action of acids, and is used as a filtering material for corrosive liquids. It is made up in a number of different forms, such as yarn, felt, boards, etc., and is employed in many fireproof cements. Asbestos is also used as an electric insulating material, but loses its insulating qualities at about 1800 degrees F., although it will recover these qualities, when cooled. It also loses its mechanical strength at the temperature mentioned, and will melt at about 2400 degrees F. In the form of asbestos paper, its puncturing voltage is about 4000 volts per millimeter (0.039 inch). As a non-conductor of heat, it has been applied to a large extent as an insulating material in electric heating devices of various types.

LATENT HEAT

When any body changes from the solid to the liquid state, or from the liquid to the gaseous state, a certain amount of heat is required to accomplish this change. This heat does not raise the temperature of the body, but is required for the molecular changes that take place within the body at the time of transformation. This amount of heat is known as the "latent heat." The "latent heat of fusion" is the heat absorbed by a solid body at the melting point, to transform it into a liquid. The "latent heat of evaporation" is the heat that is applied to a liquid at the boiling point to transform it into a vapor. When the body changes again from the gaseous to the liquid, or from the liquid to the solid state, this quantity of heat is given out by it without drop in temperature while this evolution of heat is going on.

FLOATING REAMER-HOLDERS

If a reamer is held rigidly in the turret of a machine tool, it is likely to produce a hole that tapers slightly or is too large. When a hole is bored with a single-point boring tool, it is concentric with the axis of rotation, and if a reamer that is aligned exactly with the bored hole is fed into the work, the finished hole should be cylindrical and of the correct size. It is very difficult, however, to locate a reamer exactly in line with a bored hole, because of slight variations in the indexing of the turret, or errors resulting from wear of the guiding ways or other important parts of the machine. To prevent inaccuracies due to this cause, reamers are often held in a "floating" holder. This type of holder is so arranged that the reamer, instead of being held rigidly, is allowed a slight floating movement so that it can follow, without restraint, a hole that has been bored true. In this way, the hole is reamed straight and to practically the same size as the reamer. There are many different designs of floating holders.

ELECTRIC FUSES

An electric fuse is simply a conducting element of such dimensions that it will melt at a predetermined current value, and thus break the circuit and prevent a dangerous temperature increase due to abnormal current conditions. Although arranged in many forms, fuses are simply metal strips or wires that melt, or fuse, when the current reaches the predetermined value. They are divided into two classes: (1) Those designed to protect the circuit and apparatus against both short circuits and definite amounts of overloads. (2) Those designed to protect the system only against short circuits. To the first class belong link and enclosed fuses of the National Electric Code that open on 25 per cent overload. To the second belong the expulsion fuses, which blow at several times the current they are designed to carry continuously. Fuses differ from plain over-load circuit-breakers in that they are governed by both the time and quantity of the current, while the overload circuit-breaker is governed solely by the quantity of the current.

OIL SEPARATORS

In order to purify the exhaust steam so that its condensation may be returned to the boilers, it is necessary to use some form of separator for removing the cylinder oil which it contains. There are various forms of separators in common use. In one type the entering steam is thrown downward upon an annular ring having a corrugated surface and an opening at the center. The outlet is downward from a point near the top. This construction completely changes the direction of the steam, reduces its velocity, and thus allows the particles of oil to be caught by the corrugations upon the annular ring or baffle. As the oil collects, it drips into the bottom of the chamber, from which it is trapped to the sewer or sump well through the drip pipe at the lower end. In another oil separator for non-condensing systems the separating surface consists of a baffle plate with vertical ridges, and ports at the sides for the passage of steam. The principle depended upon in the action of this separator is a sudden change of direction. The fact that the greater part of the oil contained in the steam runs along the lower surface of the pipes is taken advantage of, and the separator is so designed that it will break up the flow and drain the oil into a receptacle provided for it. The separators previously referred to are for use with non-condensing engines, where the pressure is slightly above that of the atmosphere. In cases of this kind, the oil is drained from the separator by means of an ordinary steam trap. When the engine is run condensing, in connection with a surface condenser, and it is desired to return the water of condensation to the boilers, it is evident that the oil cannot be drained from the separator in the usual manner because the pressure in the system is less than that of the atmosphere. Although the separator itself is practically the same, except in special cases, a special method of draining is required.

COAL WEIGHT PER CUBIC FOOT

The weight of coal per cubic foot or the volume of coal per ton varies according to the size of the lumps of coal and also according to the quality. On the average, one cubic foot of anthracite coal weighs from 55 to 65 pounds, and one ton (2240 pounds) of anthracite coal occupies a space of from 34 to 41 cubic feet. One cubic foot of bituminous coal weighs from 50 to 55 pounds, and one ton of bituminous coal occupies a space of from 41 to 45 cubic feet.

BALANCERS

Balancers, also known as "direct-current compensators," consist of a combination of two or more direct-current machines coupled directly to each other, and connected in series across the conductors of a multiple-wire system of electric current distribution. The object of balancers is to maintain the potentials of the intermediate wires of a system, which are connected to the junction points between the machines. When two machines are used, each carries one-half the line voltage; they are then generally employed to provide the neutral of a three-wire lighting system.

ALUMINUM OXIDE

Artificial abrasives of the aluminum oxide class, are produced in electric furnaces from bauxite, which is a soft earth, and is the purest form of aluminum oxide found in nature. The oxide crystallizes when bauxite is fused in the electric arc furnace, and because of the abrasive being artificially produced, undesirable elements can be eliminated. It is due to this fact that artificial abrasive wheels have become popular. Crystalline aluminum oxide ranges in color from white to deep wine color. Wheels made from this abrasive are recommended for grinding materials having a high tensile strength, including the various steels, annealed malleable iron, wrought iron, tough bronzes and tungsten. Aluminum oxide grains are hard, tough, and dense, and when fractured, leave sharp cutting edges.

AMALGAMS

Alloys formed by mercury and other metals are known as "amalgams." Many of these are formed by direct contact of a metal with mercury; others are formed when the metal and mercury are placed together in dilute acid. In still other cases, mercury is added to the solution of a metallic salt, or the metal is added to the solution of mercury nitrate. When newly made, amalgams are plastic, but they harden after a short time and then usually either expand or contract to a considerable extent. The most common metals that combine with mercury to form amalgams useful in the industries are tin, copper, cadmium, bismuth, silver, and gold. Tin amalgam is used for silvering mirrors. Copper and cadmium amalgams are used in dentistry, silver and gold amalgams are used in silvering and gilding, and an amalgam of zinc and tin is used in electrical machinery. Zinc plates of electric batteries are covered with an amalgam in order to reduce the polarization. Many amalgams are useful as cements for metals, the cement being applied in its plastic form when newly made, and hardening after a short interval, as mentioned.

ENTROPY

In thermodynamics, especially in dealing with steam, the change in entropy or in the "condition" of the water or steam is frequently referred to. The change in entropy, which results when the required amount of heat to raise one pound of water from 32 degrees F. to the boiling point (212 degrees F.) is added, is called the "entropy of the water"; the change in entropy during evaporation, that is, the heat of evaporation divided by the absolute temperature of the boiling point, is called the "entropy of evaporation"; and the entropy of the water plus the entropy of evaporation is called the "entropy of steam." The entropy of water is approximately equal to the quotient of the heat added to one pound of water to raise its temperature from 32 degrees F. to 212 degrees F., divided by the average of these two temperatures above absolute zero.

WATERPROOFING CONCRETE

A serious drawback to the general use of concrete for tanks cisterns, house walls, cellars, etc., is its permeability to moisture. Several formulas for making concrete waterproof have been successfully used, but some of them are too expensive for general application. One of the simplest, cheapest, and most effective is that developed by the U. S. Geological Survey. A heavy residual mineral oil of 0.93 specific gravity, mixed with Portland cement, makes it waterproof and does not weaken when the concrete consists of, say, cement, 1 part, sand, 3 parts, and oil, not more than 10 per cent, by weight, of the cement. Concrete mixed with oil requires about 50 per cent more time to set hard, and the compressive strength is slightly decreased, but not seriously. The bond or grip of oil concrete on steel is much decreased when plain bars are used, but formed bars, wire mesh, or expanded metal act as effectively in it as in ordinary concrete mixtures.

CHARCOAL AND ITS USES

Charcoal is the residue consisting of impure carbon which is obtained by expelling the volatile matter from animal or vegetable substances. The most abundant source of charcoal is wood. Under average conditions, 100 parts of wood yield about 60 parts, by volume, or 25 parts, by weight, of charcoal. The modern methods of producing charcoal from wood consist in using a cast-iron retort in which the wood is heated in order to remove the volatile constituents. Valuable by-products are also obtained in this manner (wood alcohol, wood tar, etc.). The uses of charcoal in the industries are many. It is an important fuel, especially in many metallurgical processes; it is also important as a constituent of gun powder; it is used as a filtering medium; and it has the power of removing coloring matters from solutions, and is, therefore, used to some extent in laboratory practice. The actual specific gravity of wood charcoal is 1.5, but owing to its porosity it floats on the surface of water.

AIR COMPRESSION TERMS

Upon the recommendation of its technical committee, the Compressed Air Society has adopted the following definitions of certain compressed air terms, and the society recommends that the use of other expressions of efficiency be discontinued: The *displacement* of an air compressor is the volume displaced by the net area of the compressor piston. The *capacity* is the actual amount of air compressed and delivered, expressed in free air at intake temperature and at the pressure of dry air at the suction; it should be expressed in cubic feet per minute. *Volumetric efficiency* is the ratio of the capacity to the displacement of the compressor. *Compression efficiency* is the ratio of the work required to compress isothermally all the air delivered by an air compressor to the work actually done within the compressor cylinder, as shown by the indicator cards, and may be expressed as the product of the volumetric efficiency, the intake pressure, and the hyperbolic logarithm of the ratio of compression, all divided by the indicated mean effective pressure within the air cylinder or cylinders. *Mechanical efficiency* is the ratio of the air indicated horsepower to the steam indicated horsepower in the case of a steam-driven machine, and to the brake horsepower in the case of a power-driven machine. *Over-all efficiency* is the product of the compression efficiency and the mechanical efficiency.

What Our Readers Think

on Subjects of General Interest in the Mechanical Field

ENCOURAGE YOUNG DRAFTSMEN TO VISIT THE SHOP

In some drafting-rooms where the writer has been employed, the draftsman was made to feel like a shirker if he occasionally spent a little time watching operations in the machine or pattern shop. If caught doing this, the chief draftsman would be likely to inquire what the draftsman was doing away from his drawing-board and give him to understand that the time to visit the shop was during the noon hour or before starting time in the morning and after quitting time at night. Obviously at such periods, with the machines standing idle, it is impossible to obtain anywhere nearly as much practical information as when the machines are actually engaged in productive work.

Few draftsmen first spend an apprenticeship in the machine or pattern shop before entering the drafting-room, so their practical knowledge of machining methods usually must come either through observations in the shop or from censure resulting from mistakes made on drawings. And how caustic are the comments directed to the young detail draftsman who happens to design a part in such a way that it cannot be machined! If any draftsman is to become valuable to a concern, he must obtain considerable knowledge of machining methods, and the management should encourage frequent trips through the shop during working hours. It is an excellent plan to have the draftsman follow through the machining operations of parts for which he personally has made the drawings. D. SEINER

* * *

DO WE THINK?

I read with a great deal of interest the article entitled "Do We Think?" on page 130 of October MACHINERY. Experience as a foreman in various engineering works leads me to give some of my views on this question. In the first place, it may be safely stated that there are two classes of machinists and mechanics in the machine-building and metal-working industries today. First, those who stand at their bench or machine and go through the manual motions of their work like automatic machines, and second, those who require to know why and how results are obtained and the relative importance of each step. To the latter class we are indebted for the improvements in the various branches of the mechanical field.

To the youthful mechanics I would say: Think your own jobs out, be observant of other jobs and methods of procedure in the shop, and never be afraid to inquire the reasons for anything that you do not understand. Apply all the knowledge you have, and constantly endeavor to add to that knowledge, so that your mind will be able to keep pace with all the demands made upon it by the problems that arise daily in connection with your work. By so doing, a real and intelligent knowledge of the trade will be acquired, which will enable you to take your place among the best class of machinists and highly skilled mechanics.

It is not sufficient that apprentices or mechanics should know how to do a certain job; they should know why they do it. A thorough understanding of the principles of mechanical engineering enables the mechanic to apply them to new phases of his work, and he can adapt himself more readily to the changing conditions of this progressive age.

Not a few highly skilled mechanics who may have had little education owe their success to the fact that they are excellent observers. Such men have common sense and understanding gained by close observation in the shop. Their minds are stored with a stock of useful knowledge that can be quickly applied when the opportunity is presented. Success in mechanical engineering today is achieved by the man who is ready for his opportunity when it comes.

It has been suggested that the use of pen and pencil in recording observations is an excellent means of training oneself. This is true to a certain degree, but a far better method is to train the memory to recall, as exactly as possible, what one has observed. For if there is no interest, there is no attention, and as a result, there is no memory. Our efficiency depends not so much on the ability to do everything, as upon the ability to select essentials and to cast unessentials aside. In industry, we must know what to ignore, as well as what to pay attention to. A. EYLES

* * *

MODEL WORK IN DESIGNING

An article in December MACHINERY, entitled "Feeding Devices for Automatic Machinery," contains a paragraph, on page 297, which brings out the need of model work before designing and building specialized machinery. This point interests the writer, as his contention has always been that a few hours spent in studying and developing a crude working model of complicated motions gives most satisfactory results in the completed mechanism. Putting the entire machine on tracing cloth, even to its last detail, before one is really certain of its practicability, has forced many a designer to make over his drawings needlessly. Many designers disagree on this point and feel that if sufficient time were taken in analyzing the problem, the drafting-room should be capable of turning out complete working drawings of the most complicated mechanisms without the help of model work.

The writer has noted several instances where an intermediate department for experimental work would have eliminated the necessity of rebuilding a machine before it was accepted by the production department. A machine for feeding empty paste tubes for filling may be taken as an example. This machine was designed for the operations of feeding the tube under a spout, filling it, and sealing the bottom. The first requirement was high speed of output, as previous machines of low production were already on the market. After the drawings were carefully made, the machine was built and shipped to the concern who had ordered it and installed in their factory as a regular production unit. Several features of the machine, such as a noisy feeding mechanism, due to its speed, were felt to be objectionable before it was shipped to the buyer. As the machine was built strictly according to blueprints, and the designer had no facilities for model work on questionable features, the testing of the design had to be left until the machine could be run at the factory.

The feeding mechanism referred to made even more noise under actual working conditions, in fact so much so that the mechanism could not stand up under the shocks. Breakdowns resulted and finally an entirely new feed had to be designed; in addition, parts had to be replaced. Taken as a whole, the procedure was a costly one for both the machine manufacturer and the buyer. The example cited illustrates the need for an experimental department. Had the designer worked out the untried mechanisms by means of model work, it would have been clearly seen that his first thoughts were not practical from a production standpoint.

RHODES POLLEYS

Blanking Tools for Pressed Steel

By W. E. IRISH, Works Engineer, Erie City Iron Works, Erie, Pa.

IN pressed-steel work, the blanking tool, if made in the usual way, is a considerable factor in the cost of the finished part. This is especially true when the order does not call for enough of the parts themselves to absorb any considerable tool charge. The problem then becomes largely a matter of who can build the tools the cheapest. Following is a description of what might be called a temporary blanking tool, the making of which involves only a small investment, and which practically eliminates the tools themselves from being any considerable item in the cost of the part.

W. E. IRISH, the author of the present article, graduated from Cornell University with the degree of Mechanical Engineer in 1912. Since that time he has had an extensive experience in a great many engineering fields, working first as a general machinist's helper, machinist and assembler, and later as stock chaser, chief inspector, assistant engineer, chief engineer, and works engineer. His experience has covered foundry practice, design of tools, special machines and jigs, piece-work rate setting, plant and equipment maintenance, machine and building layouts, pressed-steel stampings, material handling systems, purchase and installation of new equipment, and cost control. Mr. Irish is thirty-three years old and lives in Erie, Pa.

For illustration, an automobile cross-member has been chosen, as shown at *A*, Fig. 1. A drawing of this part, together with others that made a complete frame of material 3/16 inch thick, was sent in by a customer who called for bids on the job. The company using the method to be described obtained the business, which involved making two hundred complete sets.

Constructing the Die

The first step was to determine, in the usual manner, the shape of the blank shown at *B*. Two cast-iron platens *C* and *D*, Figs. 2 and 3, of suitable size, were taken from the stock rack and set up on horses of convenient working height. These platens were drilled and tapped every two inches for half-inch screws, and were finished on the top, bottom, and ends. A sheet of heavy wrapping paper *E* was laid on platen *C*, Fig. 2, to cover the holes, and then strips *F* were set and fastened with screws which pierced the paper and were tightened in the threaded holes.

Next the blank *B* was set on short pieces of pipe like the ones shown at *G* so that it was raised a little over an inch above the face of the platen. The blank was then fastened in position with clamps and screws through other holes in the platen on which the die was to be built. Die steels *H* were next selected from a rack previously stocked with the parts taken from worn out and obsolete permanent blanking tools, and with special shapes made for the purpose. These were set as shown against the edge of the blank *B*, which served as a pattern. Incidentally, it will be noted that the edge used for cutting, in this case, is not the same as the one previously employed for the permanent tool. It is also to be noted that each steel was ground to have shear, as shown at *H*, Fig. 4, when used in making the die. The rack in which the steel pieces were kept in stock was divided into two sections, one for the pieces having shear that were to be used for the die, and the other for the punch pieces which were flat on the top edge, as shown at *J*.

Straight sections offered no problem, and for the most part, curved pieces could be selected that would make a good fit. There were certain ones, however, like those shown at *K* and *L* that had to be prepared for the die being made. In such cases pieces were selected, when possible, that were very near the shape and size, so that they could be easily ground to the desired shape on a floor grinder provided for the purpose. When nothing could be found of nearly the required shape, another steel was selected, heated in a small furnace, and forged until it could be fitted to the proper contour with a little grinding, after which it was tempered and ground.

When the pattern had been completely encircled with the steels, conveniently located holes in the platen were selected, and fillister-head screws or cap-screws used to clamp the steels in position and keep them from shifting as the lead—in this case No. 4 babbitt—was poured. To get a good body of the lead in all sections without the use of a ladle that was too heavy for one man to handle, the space outside the steels was divided into a number of sections by clay dams *N*, Fig. 2. The lead was then poured a section at a time, and as soon as it had set, the clay was removed so the next section would pour to a good bond on the edges.

Proceeding in this manner, the entire outside was poured, allowing the lead to come about to the top of the steels. Care was taken to pour slowly as the lead came to the old holes in the steels so that setting would take place and plug the holes instead of flowing to the inside of the die. That part of the lead that did flow into the holes helped to hold the steels in place, but was not found to be necessary. The holes were therefore omitted in steels made especially for the purpose. While pouring the lead, the tops of the hold-down screws were protected by means of ordinary pipe caps.

When the outside had been poured and allowed to cool, the pattern was removed, leaving the pipe sections in suitable position to hold stripper springs. The inside was then poured. In this case the lead was run to the top of the pipe sections and the blank or pattern located above the springs for a stripper plate. The blank was, of course, set deep enough to allow the punch to enter and clear a blank and still leave a certain amount for regrinding if necessary. Under ordinary conditions such a tool is good for a thousand pieces without attention.

After the pouring was completed, the clamps were all removed from the steels, and the holding screws taken out, with the exception of those properly located for holding the lead in place. Those so located were then screwed down tight over their washers against the lead. Incidentally, it was found that the washers were unnecessary and they were therefore

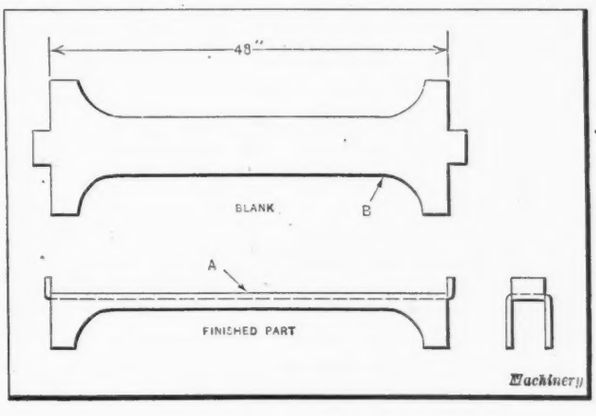

Fig. 1. Pressed-steel Part blanked in Die shown in Fig. 2

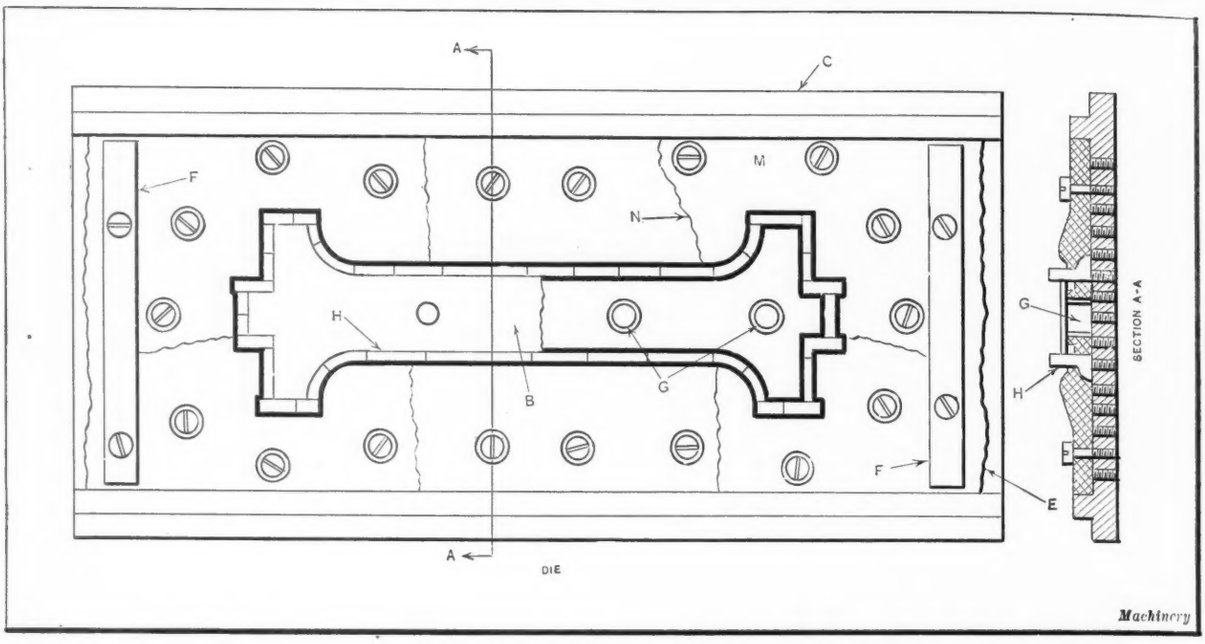

Fig. 2. Temporary Die built up from Steel Pieces held in Lead Binder

eliminated. The next operation was to calk the lead against the steels inside and out, which was done with an air hammer first, the finishing touches being put on by hand. The calking is indicated by the heavy black lines in Fig. 2. First the inside of the die was calked until the lead was tight against the steels. Then the pattern was set in place and the outside calked so that each steel was set evenly on the outline, without pinching the pattern. This completed the initial construction of the die.

Constructing the Punch

In constructing the punch, the pattern was inverted from the position used in making the die so that any irregularities in the die would match those on the punch. It was then set on the second paper-covered platen, Fig. 3, on top of several punch pieces selected from the rack and arranged under the ends and under the sides at the center. The pattern was then clamped in place, much the same as it was for the die, except that this time the steels, all flat on top, were faced out and set as shown in section *B–B*. These punch pieces were taken from the punch rack having flat-top steels, and were all of about the same height. Suitable pieces were selected and placed in position until the entire punching edge was continuous. Curved sections and irregular lines were treated the same as they had been in the case of the die.

When this had been accomplished, additional clamps were employed to hold all the pieces firmly in position. The outside was then divided into sections and poured, the molten lead being allowed to fill up the section *P* to a certain predetermined height, as in the case of the die. The pattern was next removed, additional screws *Q* being used as needed to hold the lead in place, after which the inside was poured, the molten metal filling the space nearly to the top of the steels, as shown in section *B–B*. The screws *Q* were then tightened down, both on the inside and outside of the steel pieces, and the extra screws used for clamping were removed.

The punch was calked on the inside first, as shown at *R*, Fig. 4, after which the pattern was replaced on top of the steels and clamped in place. Then the outside was calked until each steel was in accurate alignment with the outline.

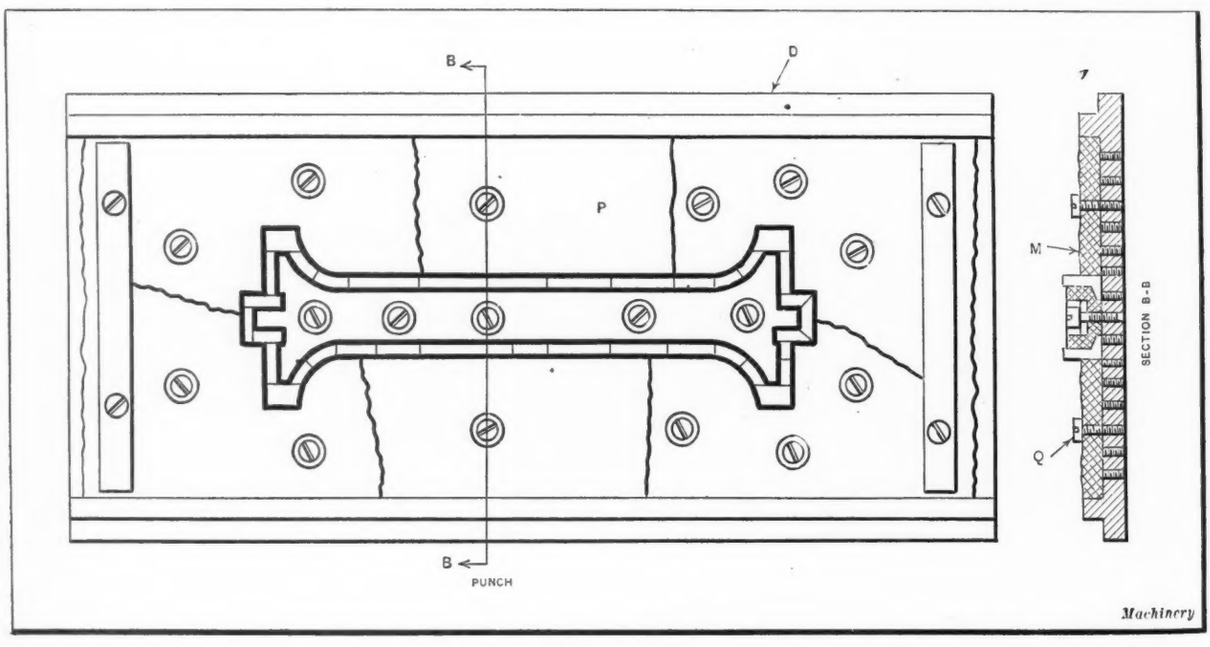

Fig. 3. Punch used with Die shown in Fig. 2

The punch and die were next fitted together with the pattern located inside the die and any excessive tightness eliminated by calking. The final operation was that of grinding the cutting edges. This was done by placing the punch and die on a stand and going over them with a swing grinder. They were then ready for the press and production.

Springs were placed in the recesses formed by the pieces of pipe used to support the pattern in the die, and the pattern set on top of these springs to act as a stripper plate. The punch was then placed in the die, and the whole assembly taken to the blanking department. The punch and the die were secured to the press ram and platen, respectively, with clamps which held to the platen edges outside the side shoulder. With the press gibs in fair condition, guide pins are unnecessary, provided care is exercised in setting up.

When the run was completed, the temporary tool was returned to the point where it had been made for breaking up. The punch was removed from the die, and the pattern numbered for future reference and filed away in a storage rack. The holding screws and end pieces such as shown at *F*, Fig. 2, were removed, and the lead pried loose from the platen with a pinch-bar and separated from the steels. The platen was put back in the melting pot, and the steels returned to their proper racks to be used again as needed.

After the blank or pattern has been determined, such a punch and die can be constructed ready for work in approximately twenty-four hours, if men are employed who are familiar with the various steps through actual practice. The cost of making the punch and die described was about $15. There is no material charge worth mentioning after the first investment in tools and after the material has been forwarded to the set-up department. Usually tools of a more permanent nature which have worn out furnish scrap material for the steels used for building dies of the type described. There is little waste of lead, and the platens are used again and again.

It is easy to see the great difference between the cost of the built-up die and that which would have been incurred for a blanking tool made in the usual manner, to say nothing of the great difference in time required for construction. The piece shown is a comparatively simple one, but it by no means represents the limit of application of the method. The steels, when only an inch long, will be securely embedded in the lead, so that very complicated outlines can be closely approximated with a series of short straight steels. If the part to be made is longer than any platen available, the two platens can be placed end to end, and both the die and the punch constructed in two pieces. Since the set-up is made in the press with the pattern in place in the die, the usual amount of care will obtain good registering at the ends.

Practice has shown the shoulder on the bottom of the steels to be unnecessary for firm location in the lead if the side opposite the cutting edge is roughened where the lead comes in contact with it. This makes it possible to put the steels into smaller spaces than could be done if there were projecting shoulders. About the only requisite in making such dies is patience and practice in the somewhat unusual methods used.

The following is a list of the materials and tools required in fitting up a department for the production of temporary dies of the kind described:

1. A supply of lead—No. 4 babbitt—sufficient for the number of tools that will be in use and under construction at any one time.
2. A supply of steels gathered from old tools with the addition of certain special shapes that may be found necessary.
3. A roll of heavy wrapping paper.
4. Patterns of the pieces to be made.
5. A stock of platens, machined and tapped and of proper size for the work to be done.
6. Clamping strips, end pieces, both from scrap, with bolts, washers, pipe, nipples, etc.
7. A lead melting pot and furnace with a pair of ladles.
8. A small muffle furnace for drawing and tempering the steels that have to be forged, and a tempering bath.
9. A floor grinder.
10. A swing grinder.

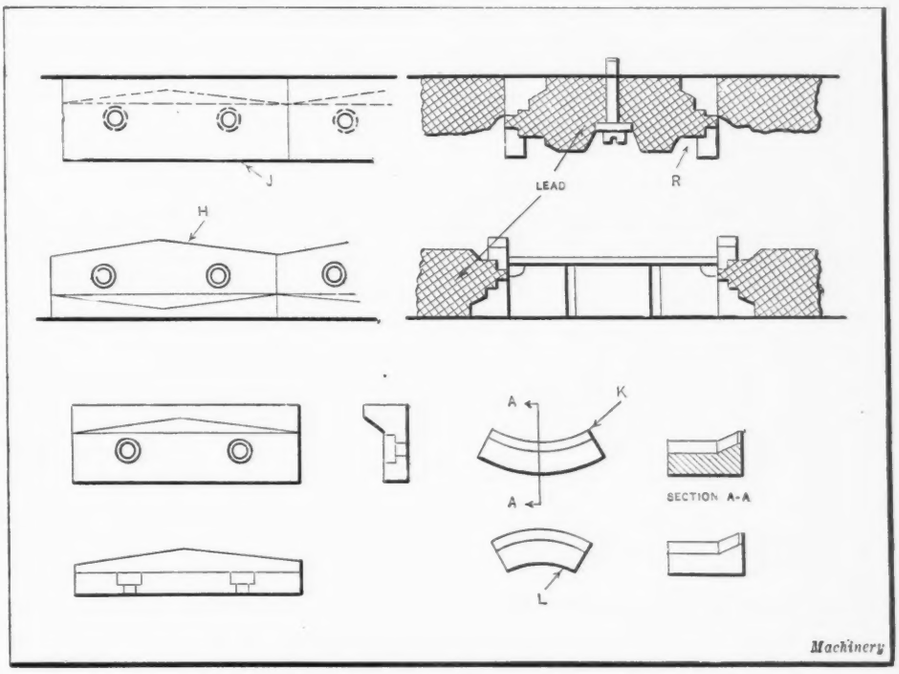

Fig. 4. Diagrams illustrating Construction of Punch and Die

11. Hammers and calking tools.
12. A crane to handle the platens and tools.

* * *

RESEARCH ON THE STRENGTH OF GEAR TEETH

Recognizing the timely importance of a study of the effects of varying degrees of tooth accuracy and varying velocities on the strength of gear teeth, the main research committee of the American Society of Mechanical Engineers, with the approval of the council, organized in 1922 a special research committee to make such a study. This committee held its first meeting in April, 1922, and requested Wilfred Lewis to serve as chairman and to begin the systematic development of the design for a gear testing machine for which he had already made rough sketches. From time to time the members of the committee recommended modifications of the original drawings. They were then carefully examined by Professor Charles E. Fuller, professor of theoretical and applied mechanics, Massachusetts Institute of Technology, who made some additional suggestions and then approved the design. At its April, 1924, meeting the committee finally approved the design and instructed the chair man to secure bids for the building of the machine. In June, 1924, the society signed a contract with the Bilgram Machine Works of Philadelphia, Pa., and the machine was completed in November. The purpose of the Lewis machine is primarily to determine the effect of varying degrees of tooth accuracy and velocities on the strength of gear teeth.

Ball Bearings Applied to Machine Tools

By T. C. DELAVAL-CROW, Chief Engineer, The New Departure Mfg. Co., Bristol, Conn.

THE most efficient machine is the one that will produce the greatest amount of work with a minimum of upkeep and consumption of power. That ball bearings produce these vital results will never be questioned by the designer, but from the lack of information on the subject, he may question regarding the value of the advantages as compared with the initial cost. In a machine in which accuracy, long life, and freedom from breakdown are essential, it will be found that ball bearings are not costly, either in their first cost or upkeep. In fact, a well fitted and accurate plain bearing often has a higher initial cost than a ball bearing, to say nothing of the maintenance or operating expense.

Figures comparing plain and ball bearings in the same machine have not been published, due, perhaps, to lack of accurate data. Therefore, the following figures regarding cost of plain and ball-bearing installations in a high-speed machine tool should be of interest. A plain bearing spindle, in which the bearing boxes were of the adjustable split tapered type, cost to build, complete, $76, with an average monthly upkeep per unit of $18.21, whereas, a ball-bearing spindle operating on the same machine and under exactly the same conditions, cost $73.10, with an average monthly upkeep per unit of $2.46. These figures are strongly in favor of the ball-bearing application, and it is rather astonishing to notice that the initial cost was even less than that of a plain bearing spindle, due, no doubt, to the fact that the cost of scraping plain bearings, which requires a highly skilled mechanic, has been wholly eliminated.

Another typical installation was a high-speed electric motor operating at 7000 revolutions per minute under extremely unfavorable conditions. Plain bearings would not stand up at all, whereas the upkeep on the ball-bearing installation was fifty cents a month. Another instance of the reliability of a ball bearing is the case of some 40-horsepower motors used to drive lineshafting in a grinding room. These motors are ball bearing equipped, and after running three years were examined and found to be in perfect condition. It is interesting to note that while lubrication was first taken care of at intervals of six months, it is now taken care of at intervals of nine months, and there is every indication that the motors can be run for one year or more without attention.

It should not be assumed that ball bearings can be successfully applied to all types of machinery, and even though their efficiency, frictional loss, and temperature rise are very nearly constant over any range of speed or load, they cannot be so efficiently applied to a machine where the speeds are low and the loads light. Where failure occurs, investigation of the bearing generally proves that it was due to either incorrect mounting, or as is more frequently the case, poor housing methods or means used to prevent entrance of dirt and foreign matter. Failure caused by inherent defects in the bearing itself are very few. Actual records covering years of ball-bearing production show that approximately 99 per cent of the bearings sold represent new business and are not for replacement. This is conclusive evidence of the long life that can be obtained from a ball bearing if correctly mounted and housed.

Three Classes of Service for which Ball Bearings are Suitable

The applications of ball bearings can be divided into three classes:

First, the class in which the major load is radial, the end thrust, if any, being very light, and where it is not necessary to maintain endwise location of the mechanism.

Second, where end thrust from either direction is of considerable magnitude, and it is essential to maintain endwise positioning of gears, worm-wheels, or similar types of mechanical elements.

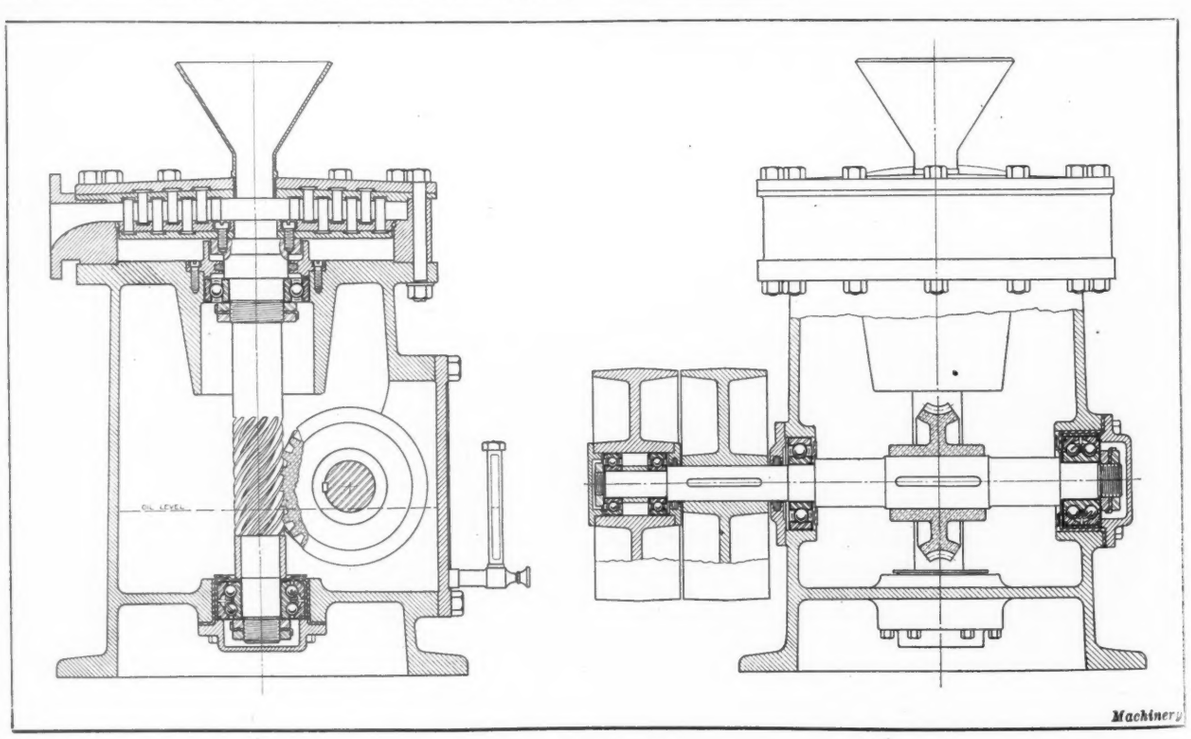

Fig. 1. Ball-bearing Mounting for a Worm Drive in a Pulverizing Mill

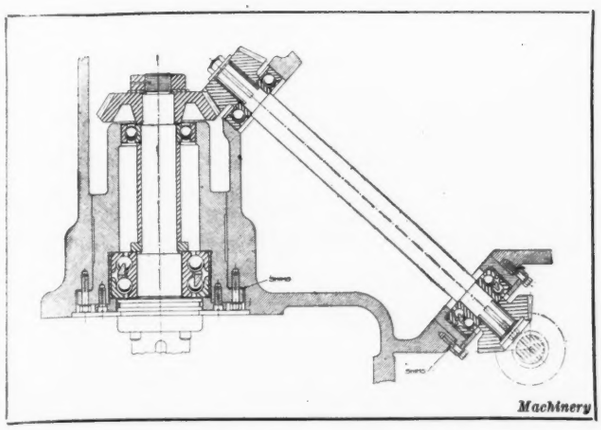

Fig. 2. Boring Mill Bevel Gear Drive equipped with Ball Bearings

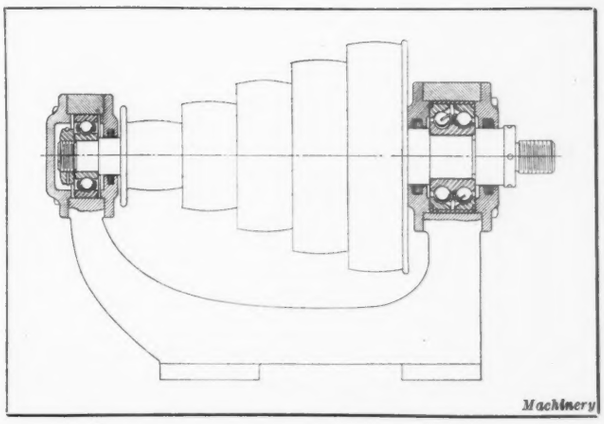

Fig. 3. Ball Bearings applied to Metal Spinning Lathe Headstock

Third, where it is necessary to obtain high speed combined with the minimum amount of vibration.

In the first case, the common mounting is to use two annular single-row bearings, both being, of course, securely mounted on the shafts with a light press fit; the press fit of the inner race is supplemented, if possible, by lock-nuts, and the outer race is a light push fit in its housing, one being securely clamped against endwise motion, and the other being allowed to float. It must be remembered that in this type of mounting endwise motion of the shaft can be obtained, the amount of movement depending upon the end thrust. This end motion of the shaft can amount to considerably over 0.007 inch in each direction when the loads are relatively light.

In the second case, the "floating" annular bearing previously mentioned, would be used to support one end of the shaft. On the other end a double-row angular contact bearing would be used, with both the inner and outer races clamped. This bearing, with its double row of angular contact balls, positively holds the gears or mechanism in correct mesh with a maximum deflection, even under the most severe thrust loads, of not over 0.003 inch in either direction. Another modification of this mounting would be the use of two single-row angular contact bearings. This is equivalent to cutting the double-row bearing in half and mounting one section at each end of the shaft. However, in this case adjusting means have to be provided so that positive contact between the outer and inner race and balls can be maintained, and considerable skill in setting up is required in order to prevent overloading. It is, therefore, not so simple to mount as the combined double-single row in which the double-row bearing is a self-contained and fool-proof unit.

In the third case, it is essential that the bearing be so adjusted as to become of the angular contact type. It may be either one in which the design incorporates an angle of contact, or an annular bearing in which the angle of contact can be created by endwise movement of the outer and inner races by means of adjusting nuts. The reason for this angle of contact is, perhaps, not at first evident, but experience has shown that this is the only type of bearing that will successfully sustain high speeds, the reason being that in an annular bearing only one-third of the balls are in contact with the raceways. Therefore, the separator or cage which spaces the balls has to transmit velocity to two-thirds of the balls in the bearing. This allows the balls to wedge in

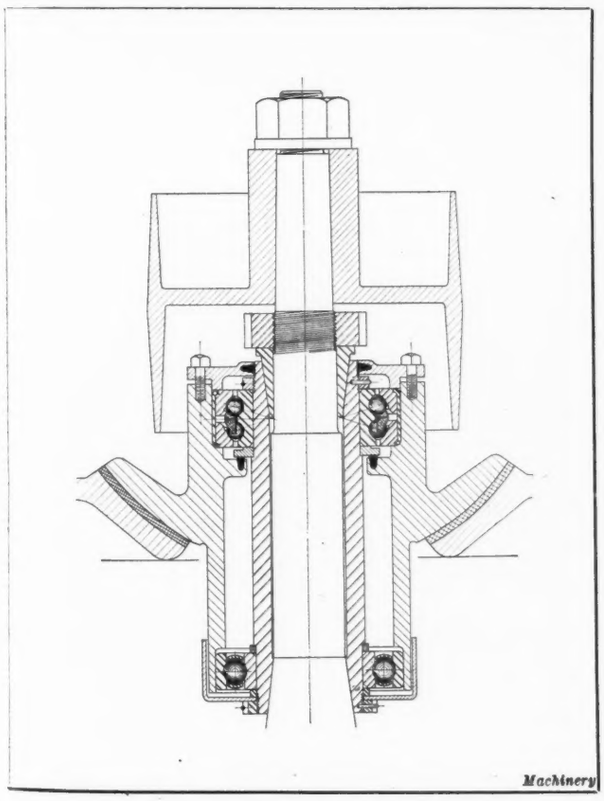

Fig. 4. Extractor Spindle mounted on Ball Bearings

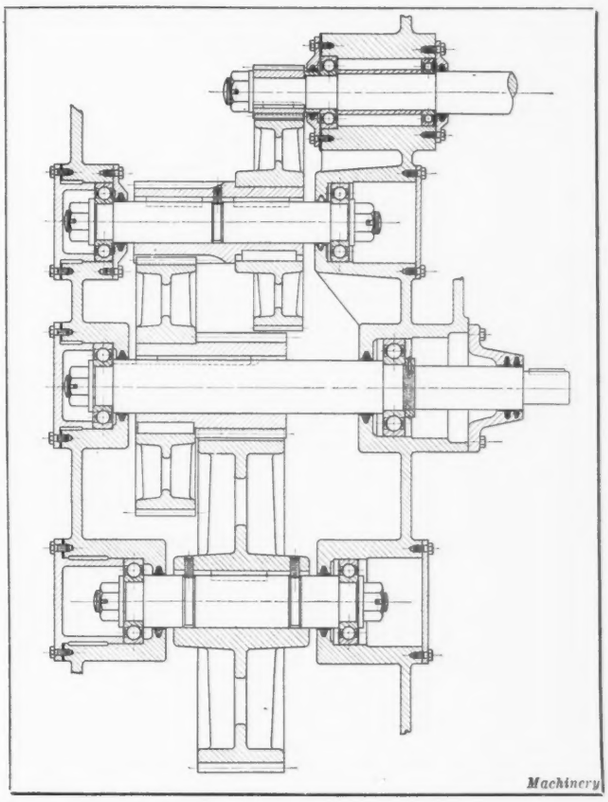

Fig. 5. Ball-bearing Equipped Planer Reduction Gearing

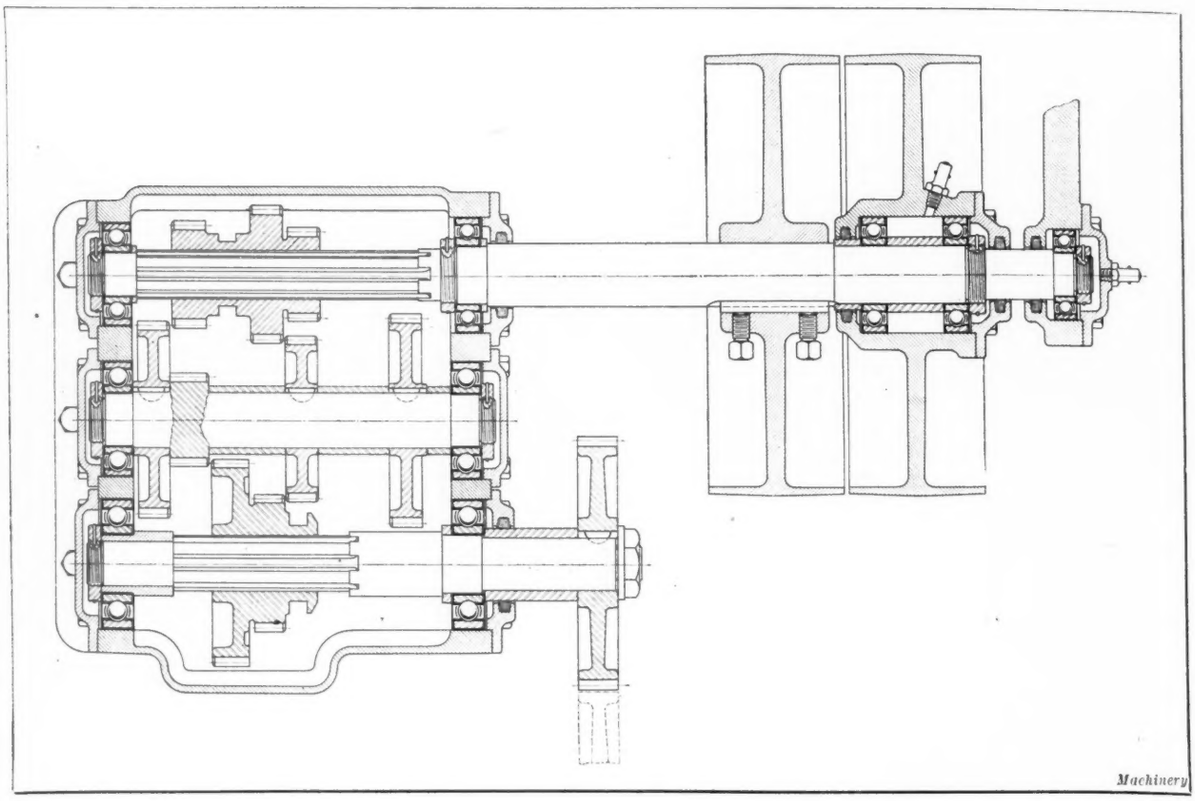

Fig. 6. Installation of Ball Bearings in a Boring Mill Drive-gear Assembly

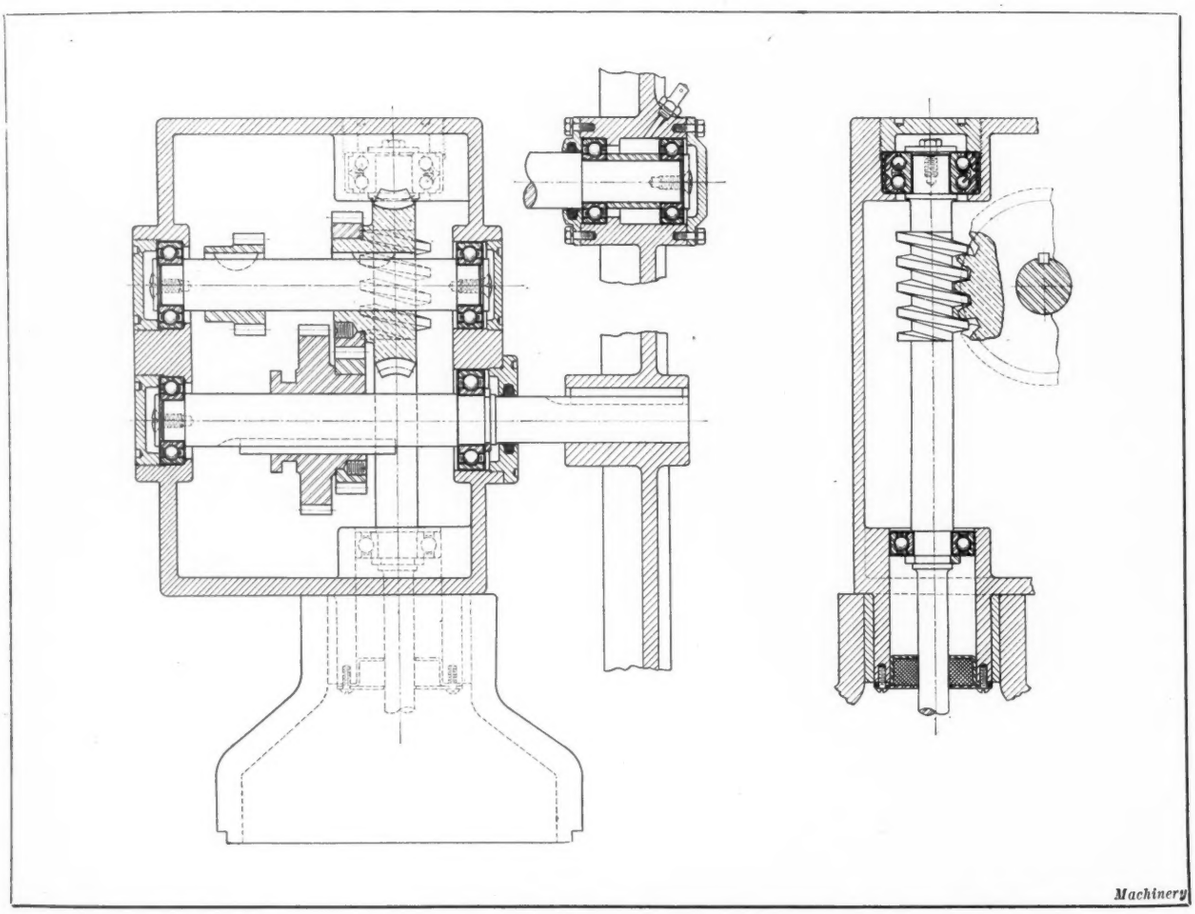

Fig. 7. Ball-bearing Installations on Metal-cutting Band Saw

the separator at high speeds, thus causing the characteristic high-speed failure of this member.

In the case of the angular contact bearing, it is obvious that if sufficient end thrust is produced, all the balls in the bearing will be in contact and will, therefore, all be driven by the rotating member, thus relieving the separator or cage of the destructive force, which is much greater than the average user of ball bearings appreciates.

Applying Ball Bearings to a Pulverizing Mill

A successful mounting of a pulverizing mill worm drive on ball bearings is shown in Fig. 1. The thrust load from the worm is sustained by a double angular contact bearing, mounted in a pressed-steel housing and clamped against endwise movement. The other end of the shaft is supported by a single-row bearing which is allowed to float, thus obviating the necessity of very accurate machining. The shaft carrying the worm is mounted in a similar manner, the double-row ball bearing at the bottom carrying the weight of the rotating parts, as well as the thrust from the worm. This is a typical mounting of ball bearings where the thrust is of a considerable magnitude, combined with a radial load, requiring positioning of the parts. The loose pulley mounting, consisting of two single-row annular bearings, one of which is locked against endwise motion, and the other allowed to float, is a typical example of bearings sustaining radial combined with a slight thrust load produced by the shifting of the belt, yet not requiring accurate positioning of the parts endwise.

Combined thrust and radial loads have to be resisted by ball bearings when used to support bevel gears of all types, and it is essential in this case that the mesh of the gear pitch circle be accurately maintained at all times; otherwise, noisy gears and failure of teeth due to crowding will occur.

Ball-bearing Bevel Gear Drive for Boring Mill

The bevel gear drive depicted in Fig. 2 shows the simplest method of supporting gears, embodying both simple adjustment and positive maintenance of pitch circle mesh. Double-row angular contact bearings are used to carry the combined thrust and radial load, the purely radially loaded end of the shaft being supported by the floating single-row annular bearing. Attention is called to the method of mounting the double-row bearings in a sleeve, the correct adjustment of gears being obtained by means of shims which are inserted between the flange of the bearing housing and the machine frame.

Metal Spinning Lathe Headstock Equipped with Ball Bearings

Another successful use of the double-single row mounting is in a metal spinning lathe headstock, as illustrated in Fig. 3. In many classes of this kind of work, considerable end thrust is imposed on the spindle during the spinning process. The use of a double-row bearing in the front end not only simplifies the construction, but also is more efficient, as it is a unit that will take care of the radial load due to belt pull and spinning tools, as well as any end thrust from either direction. The end farthest from the chuck is supported by a single-row bearing which is allowed to float endwise.

Ball-bearing Equipped Extractor

Ball bearings are also applied in centrifugal separators, the combined double-single row mounting being used very advantageously, especially as in some types it is necessary to mount bearings in a compensating housing to allow for the out-of-balance of the load when the separator is first started. A mounting of this type is shown in Fig. 4. The ball bearings are mounted on a sleeve or quill independent of the supporting shaft. This sleeve is located against a suitably formed taper on the shaft by a tapered bushing and lock-nut, the housing, in turn, being provided with a curved flange to form a ball and socket joint.

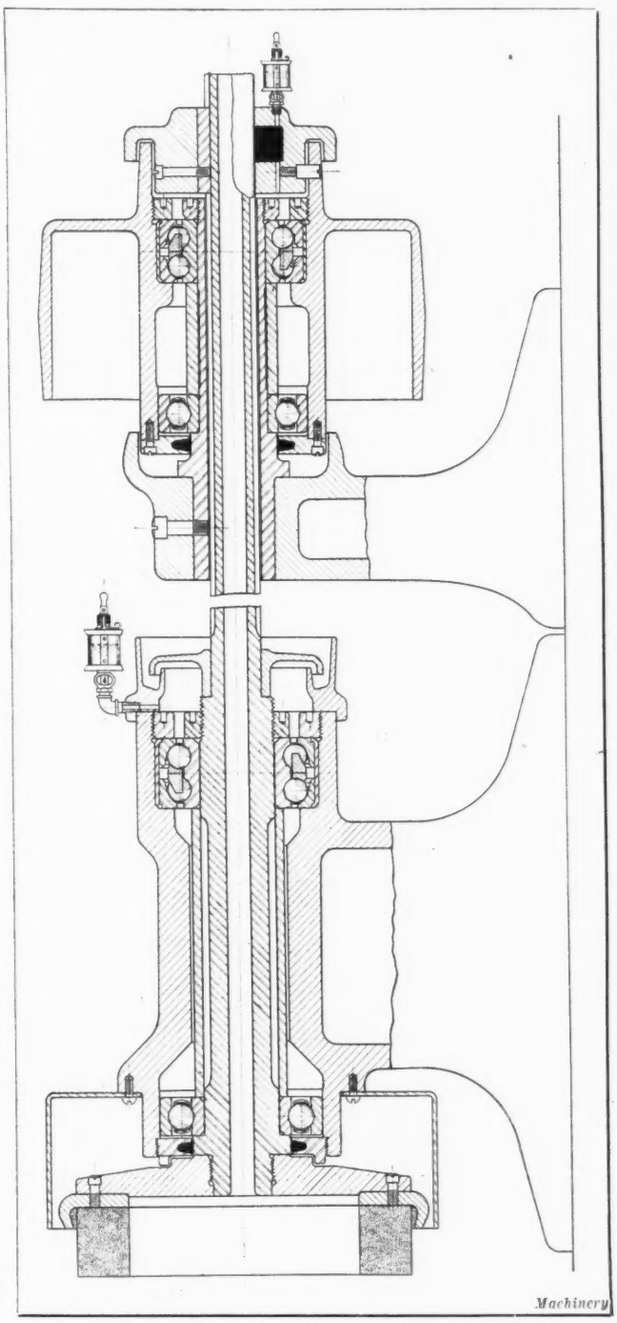

Fig. 8. Vertical Grinder Spindle

Application of Ball Bearings to a Boring Machine

The use of the automobile type of gear-box in modern metal-cutting tools is one of the fertile fields for ball bearings. The drive-gear assembly of a boring mill of the type illustrated in Fig. 6 is an excellent example of refinement in machine tool design. The gear-box has six different speed ratios. All shafts are supported by annular single-row bearings, which are installed with a clamped inner race, the outer race being allowed to float endwise approximately 1/64 inch. This obviates the need of very accurate machining, and at the same time prevents excessive end motion when shifting belts or gears. The single-row type of bearing, contrary to usual opinion, will carry as a thrust load, a considerable percentage of its radial capacity as combined thrust and radial load, provided the mounting conditions are correct and the resultant from the combined loads is within the rated radial capacity of the bearing. It will be noted that the bearings increase in size as the speed is reduced to take care of the increase in radial load due to power transmission at lower speeds. The effective ball-bearing installation in the loose pulley should be particularly noted. This eliminates bearing trouble, which frequently occurs when plain bearings are employed and lubrication neglected.

Ball-bearing Equipped Planer Reduction Gearing

The gear reduction of a planer, as illustrated in Fig. 5, is an excellent example of correct mounting practice; the inner races are locked on the shafts, while the outer races are a light push fit in their housings. One bearing on each shaft is used to position the parts by locking the

outer race, the bearing at the other end being allowed to float endwise.

One of the desirable elements in simple mountings is demonstrated in the metal-cutting band-saw gear-box and wheel application shown in Fig. 7. The method of securing the inner ball race on the shaft by means of a flat washer and countersunk screw, as well as the snap-ring used to secure the inner race of the annular bearing on the wheel-shaft may be successfully employed where the loads are relatively light, thus permitting speedy assembly and a saving in cost due to the elimination of the necessity for cutting large-diameter threads for the clamping nuts.

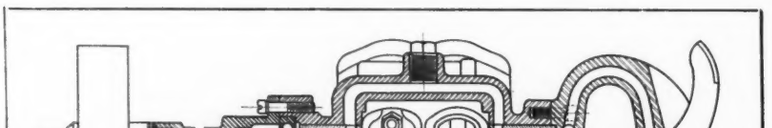

Fig. 9. Pneumatic Grinder equipped with Ball Bearings

Vertical-spindle Grinder Equipped with Ball Bearings

There are some duties for which ball bearings are peculiarly adapted, and numerous machines have been made more efficient by their use. This applies particularly to such types of machinery as the moderately high-speed vertical grinder illustrated in Fig. 8. The driving pulley is carried on the previously mentioned mounting of double- and single-row ball bearings. These bearings are mounted on a non-rotatable quill, thus relieving the spindle proper of all belt loads. The spindle, which is driven by means of a splined coupling at the top of the pulley, is so mounted on a similar double-single row mounting that the wheel weight and thrust load from grinding is entirely taken by the double-row bearing, the single row being subjected to radial loads only.

Application of Ball Bearings to Pneumatic Grinder

Because of the very low friction coefficient of ball bearings, they are well adapted for application to a pneumatic grinder, as illustrated in Fig. 9, so that wear is reduced to a minimum and maximum power is delivered to the wheel. Owing to the nature of the loads imposed upon the crankshaft, single-row bearings are adequate, the bearing at one end being allowed to float, while the shaft is clamped against endwise motion by having the outer race of the other bearing positioned in its housing. The wheel-spindle is supported by angular contact bearings so mounted as to absorb the thrust in either direction, as well as to carry the radial loads, thereby relieving the main crankshaft bearings of loads imposed by the contact of the grinding wheel with the work.

Ball-bearing Electric Motors

Ball bearings in electric motors are nearly a positive assurance against failure due to burnt out armature windings caused by leakage of the lubricant from the bearing. Also, as wear in the bearing is eliminated, a smaller air gap can be allowed, thus increasing the electrical efficiency. The motor-driven die-forming machine shown in Fig. 10 is, of course, of small horsepower, but the same principle can be applied to electric motors of any capacity. The motor bearings are silent in operation, and have excellent lubricating facilities. They require lubrication and attendance only at extended periods. It is also of interest to note the ability of the double-row bearing at the top of the cutter-spindle to withstand combined radial and thrust loads from any direction, and it readily supports the weight of the spindle when running free or opposes the pull of the cutter.

Another interesting application of ball bearings to a motor-driven unit is the high-speed portable electric screw-driver shown in Fig. 12. The speed of the motor, namely, 10,000 revolutions per minute, renders it highly impractical to use any type of bearings other than ball bearings for the support of the armature. Any other kind will quickly wear loose, eventually destroying the balance of the revolving parts and resulting in a noisy tool, which is difficult to

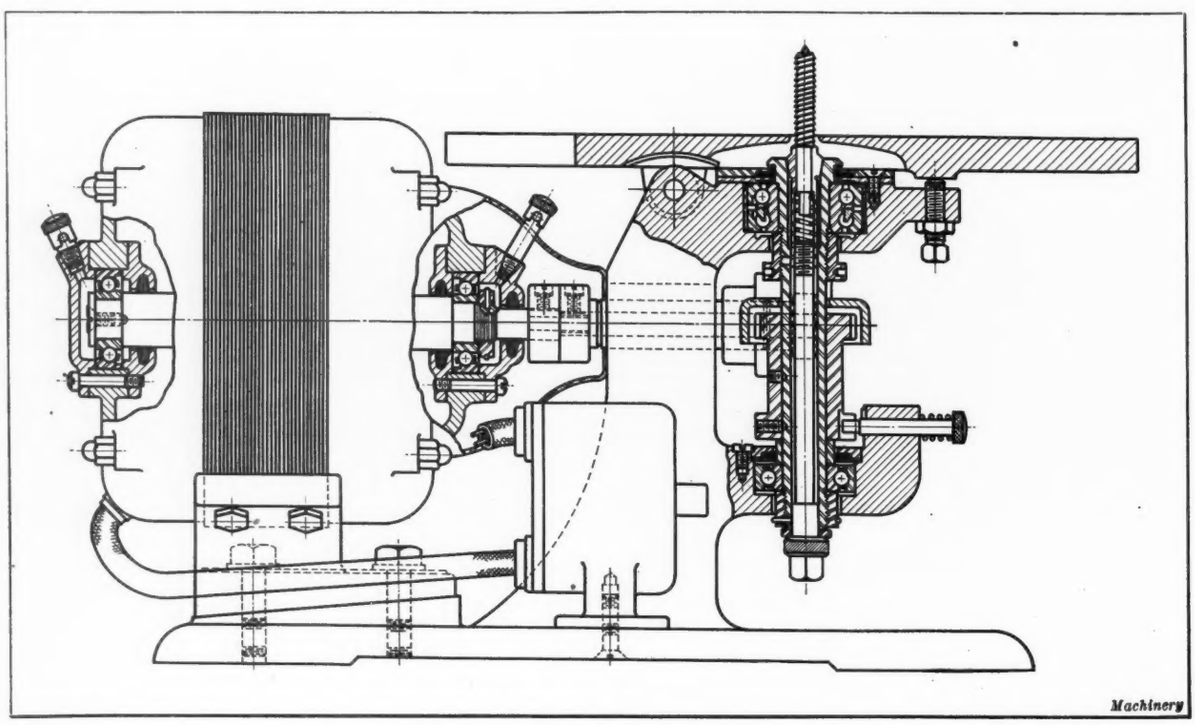

Fig. 10. Ball-bearing Motor-driven Die-forming Machine

hold in place while operating.

Attention is called to the angular contact type of bearing used to support the armature. The inner races are abutted against suitable shoulders on the shaft, the outer race on one end being held securely against endwise movement in one direction, and the outer race on the opposite end abutting against a threaded nut which is so adjusted in the initial set-up that sufficient thrust load is created to cause all the balls to come in contact, thus overcoming any likelihood of vibration or chatter due to a loose bearing. In addition to the armature shaft, the worm-shaft also is mounted on ball bearings. Here there is the thrust of the worm to be considered in conjunction with the radial load. As this thrust is in one direction only, it is readily taken by the bearing shown at the forward end of the shaft.

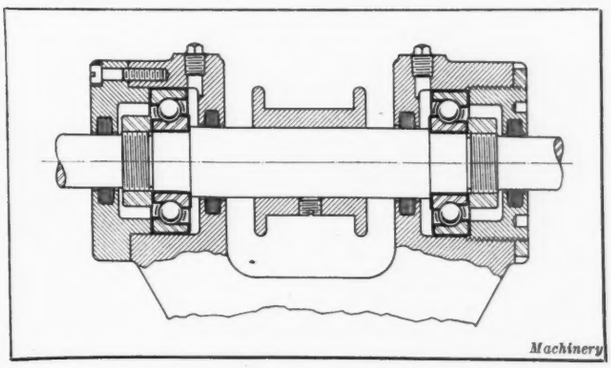

Fig. 11. High-speed Ball-bearing Grinder Spindle

High-speed Precision Grinder Spindle

Another illustration of the application of bearings to high-speed spindles is seen in Fig. 11, which shows a grinding wheel spindle that has been successfully used for grinding accurate tools. The bearings themselves are of the angular contact type, the inner races being mounted on the shaft in the conventional manner. The hard outer race of one bearing is abutted against the dust-excluding cap, which is securely screwed to the main casting. On the other end, the dust-excluding cap is threaded on its outer diameter and provided with a lock-nut. It is readily seen that the thrust can be created in the bearings by means of this adjustment, causing practically all the balls to be in contact with the inner and outer races, thus eliminating any radial clearance and relieving the separator or ball cage of the severe forces present in a high-speed bearing if this adjustment is not made.

The application of ball bearings to lathe heads and milling machines is practically, at the present time, a virgin field, and is still in the experimental stage. There is considerable research and experimentation to be done in this field, but if the machine tool builder and the ball-bearing engineer will work together, the various problems can be successfully worked out so that a saving of power and reduction in manufacturing costs will result.

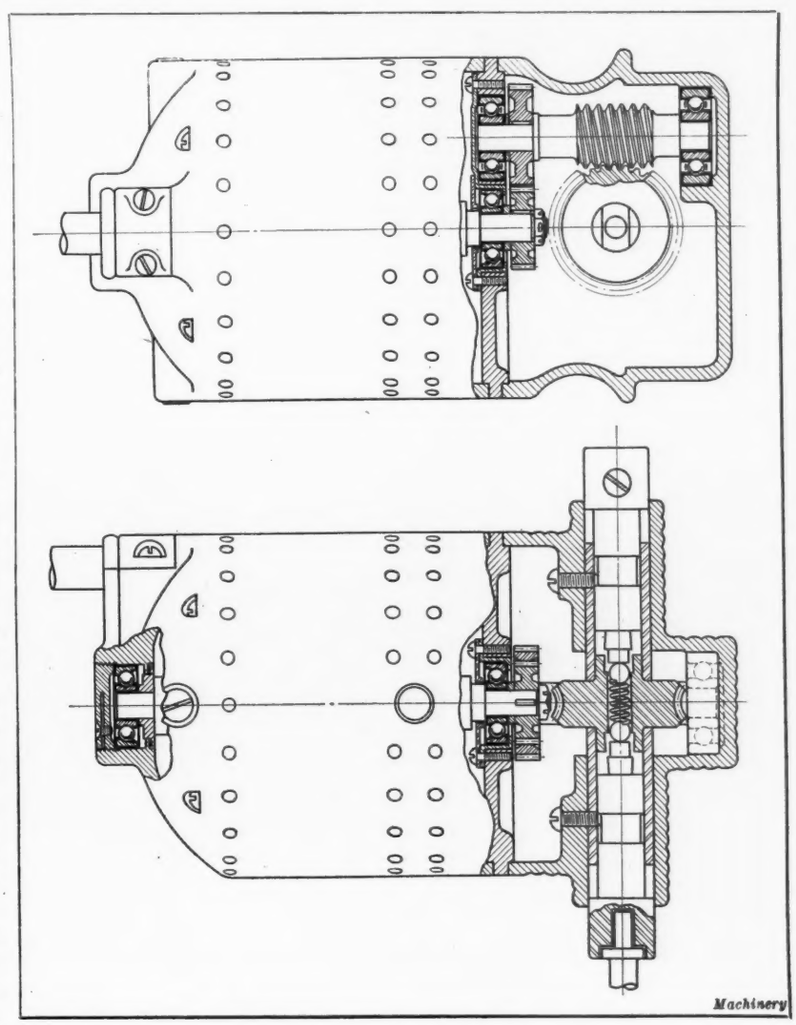

Fig. 12. Portable Electric Screwdriver

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EXPORT SERVICE

The Commercial Intelligence Division of the Department of Commerce has available a series of trade lists of interest to exporters of machinery. These lists contain the names of importers and dealers in machinery in foreign countries, and may be had without charge from any of the district or cooperative offices of the Bureau of Foreign and Domestic Commerce, or from Washington. In addition to the periodic compilation of trade lists of foreign dealers in machinery, the division has on file detailed sales data on more than 100,000 foreign firms and individuals with which American firms do business. Over 1000 American trade representatives stationed abroad cooperate with the division in keeping this data up to date.

* * *

THE BLAST FURNACE BAROMETER

According to Colonel Leonard P. Ayres of the Cleveland Trust Co., Cleveland, Ohio, the simplest and best forecast of general business conditions available is the number of pig iron furnaces in blast at any given time. At present there are 411 blast furnaces in the country. If 247 of these are in blast, which is approximately 60 per cent of the total number, business may be considered normal. The percentage of furnaces operating at the present time has not yet reached the 60 per cent line, although it is constantly climbing upward.

It is interesting to recall that more than a year ago Colonel Ayres' charts suggested that business would continue to decline in its course all through 1923 and into 1924 until about July and August. It is pointed out in *Commerce and Finance* that at the time very few believed his forecast, but actual conditions later verified it. Colonel Ayres, himself, says that his charts are still largely experimental, but, nevertheless, his work is gaining recognition, because of the care with which it is carried out.

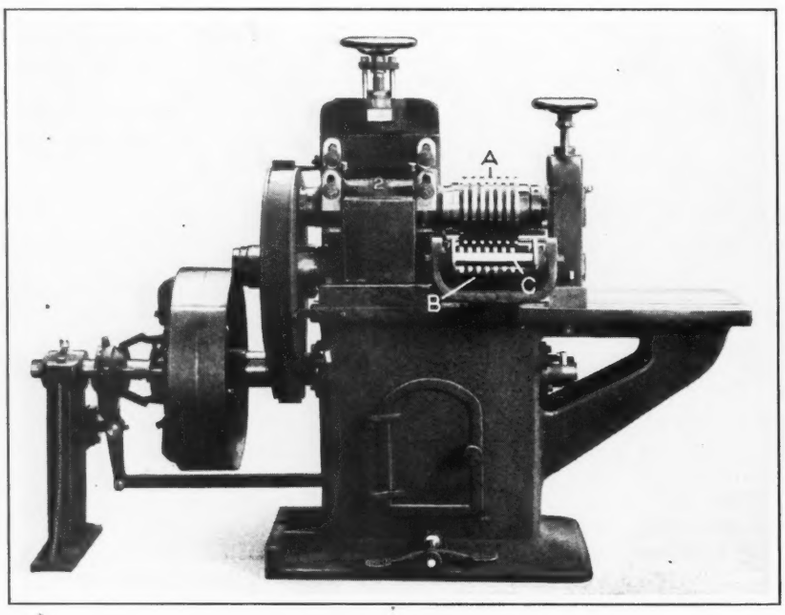

Fig. 1. Gang Slitter arranged for cutting Narrow Strips

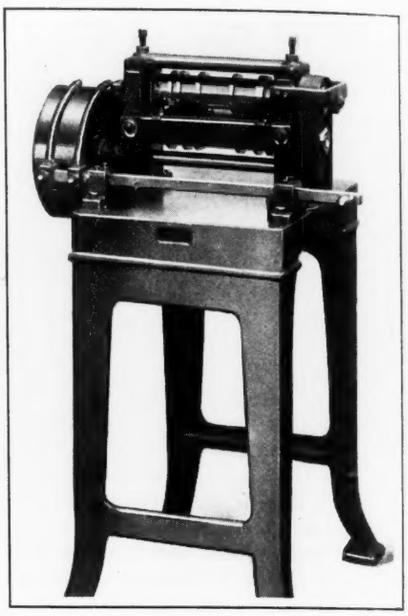

Fig. 2. Machine for handling Thin Stock

Gang Slitters in the Cutting-up Shop

By F. R. DANIELS, The Waterbury Farrel Foundry & Machine Co., Waterbury, Conn.

GANG slitting machines, although they have been commonly used for years in sheet-metal rolling mills, are not so generally employed in the cutting-up shop. "Cutting-up shop" is a term applied to those shops in which sheet metal is cut, drawn, formed, or otherwise fabricated into sheet-metal articles. This industry has grown rapidly during the last few years due to the fact that many articles that were formerly cast are now being made of sheet metal.

The manufacturer of this line of goods must ordinarily use the commercial widths of strip metal furnished by the rolling mills, which often results in great waste, because in many shops there are no convenient means for slitting the metal into widths that will result in a minimum of scrap. The gang slitting machine, therefore, is a valuable possession for this kind of work, not only because it saves considerable stock that would otherwise be sold as scrap, but also because it greatly reduces the cost of obtaining special widths from the mill and obviates the attendant delay. The slitting charge of the rolling mill will generally amount to much more than the cost of slitting commercial widths already in stock at the shop. The machines are used for two general purposes: (1) in the rolling mill for trimming the edges of wide sheets to commercial widths and (2) for slitting these sheets into strips of standard or special widths.

General Design

The machines suitable for the cutting-up shop resemble a milling machine, except that there are two cutter-spindles in place of one. These spindles are so geared together that they run toward each other in such a manner as to allow for vertical adjustment for metal of different thicknesses.

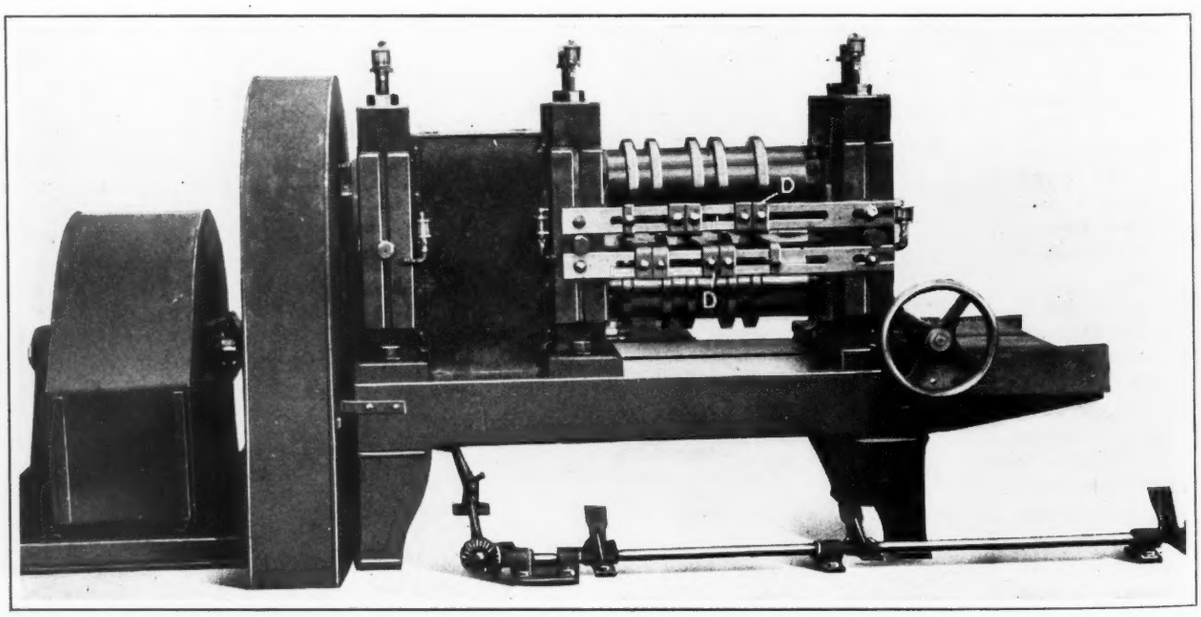

Fig. 3. Rolling Mill Type Heavy Gang Slitter with Geared Motor Drive and Friction Clutch

The spindles are supported at the outer ends by a removable tail-stand, for convenience in setting up. The illustration Fig. 1 shows such a machine arranged for cutting narrow strips. The cutters at *A* and *B* are plain disks or rings of hardened steel placed on the spindles and arranged with spacing collars between them so that the opposed cutters on the two spindles are offset to produce a shearing cut.

The stock is fed over an adjustable guide *C* at the front of the machine, and the strips pass between the cutters in the space produced by the collars. The strips are prevented fom coiling around the spindles by means of fingers, usually located at the rear of the cutters so as to extend in between them with just enough clearance between each finger and the opposed cutter to allow the metal to pass through without binding. These stripper fingers are made in various ways, some of cast iron separately attached to a bar, some of sheet metal in the form of a comb, and others of wood or fiber; the latter materials being used if plated metal is being slit.

Various attachments may be used with these machines for cutting up scrap when the metal is being trimmed only, and for coiling the metal as it is cut into strips; these attachments are necessarily applied at the back of the cutters. If either of these appliances is used, it is often necessary to attach the stripper fingers at the front in the manner indicated at *D* in Fig. 3. The machine shown in this illustration is the type used in rolling mills, but it also has application in the cutting-up shop for handling the heavier gages of metal. It will be noticed that the stripper fingers, which are made of sheet metal, are attached to bars on which they can be adjusted to suit the spacing of the cutters. The advantage of this type of machine over that shown in Fig. 2, is that the tail-stand can be adjusted to accommodate varying widths of metal, whereas in the other machine the tail-stand is non-adjustable.

The style of slitting machine shown in Fig. 2 is suitable for light gages of metal and for those shops that do not manufacture a wide variety of work. It is basically of the same design as the machine shown in Fig. 1, except that it is intended only for thin metal, and is driven by means of tight and loose pulleys instead of by a friction clutch pulley.

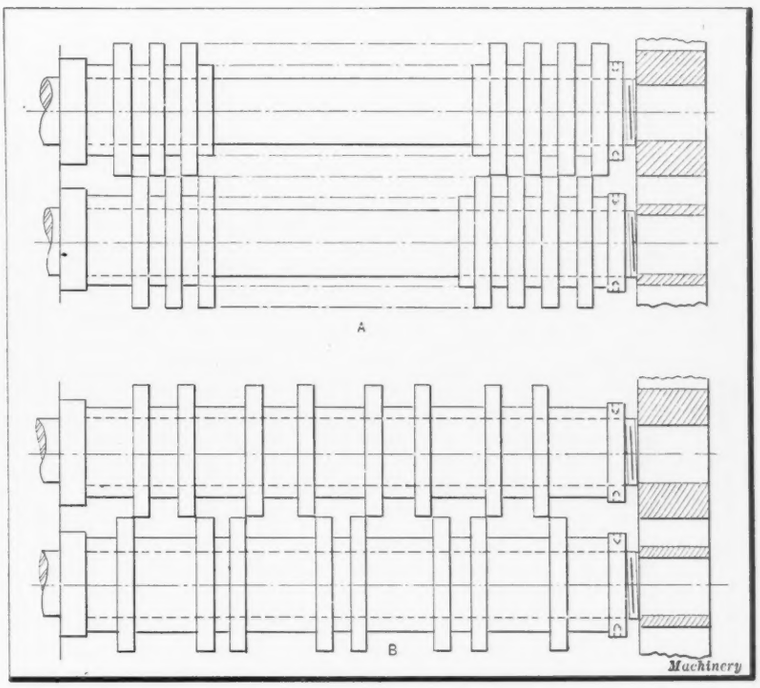

Fig. 4. (A) Arrangement of Cutters when they are the Same Width as Strips; (B) Arrangement when Strips are Wider than Cutters

Cutters and Cutter Mounting

The illustrations Figs. 4 and 5 show various methods of mounting the cutters for different conditions. In the arrangement shown at *A*, Fig. 4, the spacing collars and cutters are of the same width, being intended for cutting narrow strips. The cutters and collars are placed on the spindles and clamped with a nut from the end. The tail-stand is then moved over to support the ends of the spindles. With the arrangement shown at *B*, the strips are considerably wider than the cutters, calling for the use of spacing collars of different widths.

In Fig. 5 at *A* is shown a gang assembly of cutters in which both the cutters and collars are clamped permanently on a sleeve instead of directly on the spindle, so that the sleeve and cutters can be removed as a unit for grinding and readily replaced without disturbing the setting. Of course this arrangement is not advisable except in cases where a large quantity of strips of the same width is being slit.

At *B* in this illustration is shown the use of cutter-heads. Cutter-heads are more generally used for trimming operations than for slitting, and they can be located on the spindles in any position to give any desired width. However, adjustable cutter-heads should be limited to comparatively light gages of metal, because on the heavier metals they have a tendency to creep on the spindles and thus produce strips that are not parallel.

The method of mounting the cutters, that is whether they should be set to overlap each other slightly or whether they should have a slight clearance between the cutting edges, depends considerably upon the kind of metal and its thickness, and the best results are obtained only by experiment. Regardless of the method of mounting, the cutters should be kept sharp and free from nicks, and all

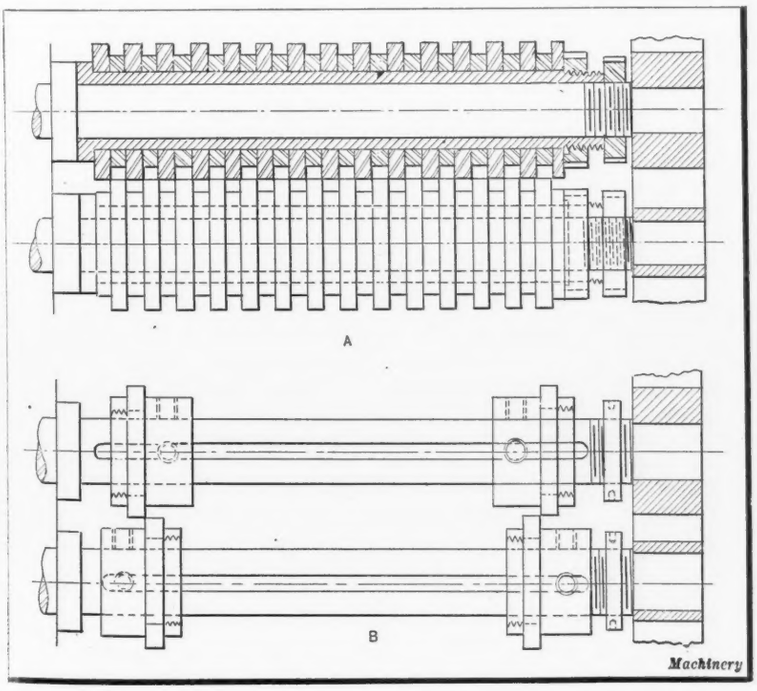

Fig. 5. (A) Cutters clamped on a Sleeve, which facilitates setting up and grinding; (B) Adjustable Cutter-heads used for trimming Edges of Thin Metal

cutters of a set should be of the same diameter. In sharpening, the cutters should be ground on the periphery only—never on the sides. Dull cutters result in burrs, and burrs are objectionable because strips that have burred edges cannot be fed automatically through rolls to the power press.

Speeds and Capacities

The speeds at which these machines should run in order to give the best service vary with the thickness and physical qualities of the metal. Ordinarily they are operated at a speed of from 70 to 120 feet per minute for sheet brass. A machine rated for handling strips 12 inches in width will make twelve cuts at a time on sheet brass 1/32 inch thick, or four cuts at a time on sheet brass 1/16 inch thick; an 18-inch machine will make eighteen cuts at a time on 1/16-inch brass, nine cuts at a time on 3/32-inch brass, six cuts on 1/8-inch brass, or four cuts on 5/32-inch brass. Machines that will take other widths than these have cutting capacities proportionate to those mentioned.

The number of cuts obtainable on soft steel is about 75 per cent of what can be expected for sheet brass, and on hard metal, like high-carbon steel, the capacity is proportionately decreased with the increase in shearing strength of the metal. Machines of the type shown in Fig. 3 are intended for much heavier service than is ordinarily imposed by the cutting-up shop, and the capacity ratings of these machines are arbitrarily determined. For example, this machine will take metal up to 20 inches in width and will make four cuts on sheet brass 3/8 inch thick, and a proportionately greater number on thinner metal.

The machines illustrated in this article represent a few of the many sizes and kinds of gang slitting machines manufactured by the Waterbury Farrel Foundry & Machine Co., Waterbury, Conn., who also manufactures complete tooling equipment and attachments for gang slitting machines.

* * *

THE APPRENTICESHIP PROBLEM

By A. EYLES

I have been much impressed with the articles on apprenticeship systems published from time to time in MACHINERY. I believe that apprentices' pay should be determined individually, and should be based upon the progress the boy is making at his trade. Also, the apprenticeship should terminate when the boy is actually doing the work of a skilled mechanic. He should then be recognized as a skilled journeyman, whether he has served two, three, or ten years as an apprentice. Employers should do their part by refraining from taking advantage of any boy's particular ability to bring profit to the firm to the detriment of the boy's progress.

That the standard of individual efficiency in many skilled trades is gradually being lowered is generally admitted. This fact indicates that the methods of training for work in the engineering field have not reached the desired state of completeness. This, to a great extent, may be traced to the ever-widening breach between the recognized leader and the apprentice. The machinist foreman was formerly anxious to inculcate in the minds of his apprentices a good knowledge of the trade, while the modern foreman is much less of an instructor and more of a production man.

The future prosperity of the machine tool and general engineering industries depends to a large extent on the way the apprentice is trained. The problems ahead will have to be solved by the rising generation, and in view of the continually increasing demands of the engineering world for high-grade machine tools, it is imperative that a higher standard of knowledge and skill should be developed among mechanics. Compensation is not so important to the apprentice in the long run as proper and adequate training. Moreover, it is the inadequately trained apprentice that is the migratory mechanic.

Observations made by the writer during the last ten years in a large engineering works indicate that it is exceptional to find a young man who is thoroughly competent to handle all the branches of his trade on completing his course of apprenticeship. The question may, therefore, be reasonably asked: Which system of apprenticeship at the present time produces the more efficient mechanic—the indentured or the unindentured system? Probably many readers will say the difference is only in name. This is partly true, but the writer has a leaning toward the unindentured boy because he is aware that if he does not give his best services he is likely to be discharged.

Apprentice Instructors

A boy should be given every opportunity in the shop to enlarge his knowledge of the trade, and an occasional opportunity to work in other shops or in other departments will be beneficial to him. Preferably, the work of the boy should be directly supervised by a foreman, or, in the case of very large shops, by a capable instructor, who is primarily interested in the quantity and quality of the work performed, as apprentices require careful and individual instruction, rather than the chance advice of any workman. The instructor does not interfere with the foreman, but rather supplements him by taking the task of instruction off his hands. Discipline remains as heretofore in the hands of the foreman. To succeed as a highly skilled all-around mechanic, the boy must combine practical and theoretical knowledge. He should be encouraged in technical study which may consist of attending night schools or studying technical literature. Manual work and study sandwiched together is necessary in training apprentices to meet the requirements of the machine-building industries.

Keeping Informed on New Developments

No mechanic, however skillful he may be or however excellent his opportunities of acquiring knowledge and experience, can without serious loss, neglect the recorded experience of others. The best and most successful engineers know that they have to read and study; that they must keep themselves informed as to the trend of new developments and the possibilities and limitations of new apparatus and processes. MACHINERY contains, I think, the right kind of technical literature, enabling machinists and mechanical engineers to make use of the practical knowledge that others have gained in the school of experience.

Opportunities for advancement in the machine-building industries and in mechanical engineering are continually presenting themselves to those who have trained their brains to think and who have gained the skill or manual dexterity required in their trade. In conclusion, it should be emphasized that in the metal-working and machine-building industries we do not want a revival of the old-time apprenticeship system, because it was designed to fit the age of hand production when master and apprentice often worked side by side. It must be modernized to fit into the scheme of present-day production. Our hope lies in education and in the thorough and all-around training of the hand as well as the brain.

* * *

GERMAN MACHINE TOOL INDUSTRY

According to "German Trade Reports and Opportunities," published by the American Chamber of Commerce in Germany, the German machine tool industry at the present time is experiencing a severe depression, and the builders of large and heavy machine tools especially are suffering from lack of orders. The number of working hours have been reduced, and some plants are planning to close their shops temporarily. It is stated that the prices obtainable both in the domestic and export trade do not cover manufacturing costs. German manufacturers, pointing to the progress made by foreign competitors, are demanding a heavier protective tariff on machine tools, and it is said that very likely the present import duties, which are based upon weight, will be increased, and that the introduction of an ad valorem duty may be looked for.

Designing Automatic Packing Machinery

By ALBERT A. DOWD

AN interesting problem in packing is shown in Fig. 1. Nearly all packing problems require the feeding of different kinds of units to a given position and then assembling them in a certain position. In this example there are 480 tablets of the form shown at *A* to be packed in a wooden box *C* in layers, as shown. Between each layer there is a piece of cardboard *B*.

Fig. 2 shows in diagram form some of the problems involved in this design. In the first place, the carrier or magazine and any other units used in handling the tablets, must be designed so that normal variations in the size of the pieces will not cause trouble. It is a good idea to place a number of groups of eight pieces each, in line as shown at *A*, and measure the maximum length as well as the minimum of the different groups. By so doing, one obtains limits within which the feeding and holding devices must be made. The diameter of the tablet probably varies slightly, and it also should be measured carefully and the maximum diameter determined. The cardboard spacer *B* must be measured for width and length as well as thickness. If several lots of cardboard are available, each should be measured to find out whether there are variations in size.

As the pieces are to be arranged in rows, the chutes should be made in multiple form, preferably eight pieces wide as shown at *F*. It is necessary to use a guide strip *E* between the pieces to keep them in line, so the clearance allowance must be carefully made, and center distances *D* must be sufficient to allow for variations in the diameters of the tablets. It may be necessary to use a very thin separating strip *E* in order that the total distance *C* will not be greater than the dimensions of the inside of the box. The wooden boxes are likely to vary sometimes as much as ⅛ inch in the outside dimensions *D*, *E*, and *F* (Fig. 1). Suitable allowances, therefore, must be made to cover this condition on all units that handle the boxes. Such points as these are, of course, well known to the experienced designer, but the man unfamiliar with this kind of work may measure up

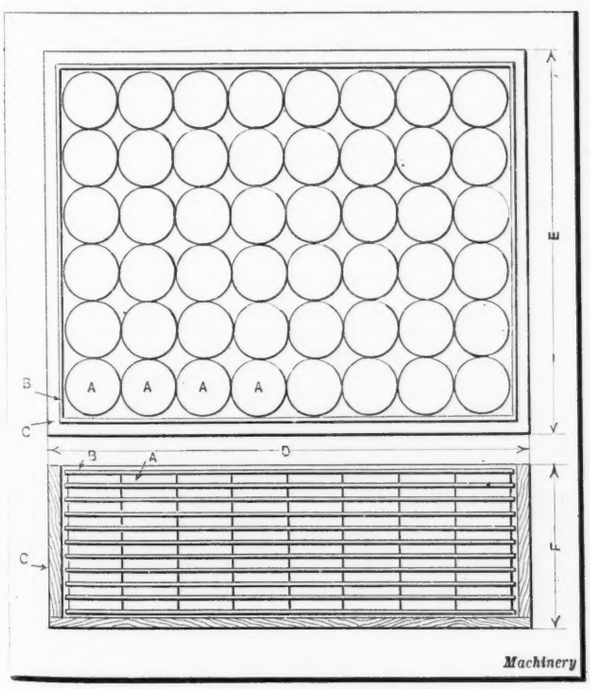

Fig. 1. Example of Packing Problem

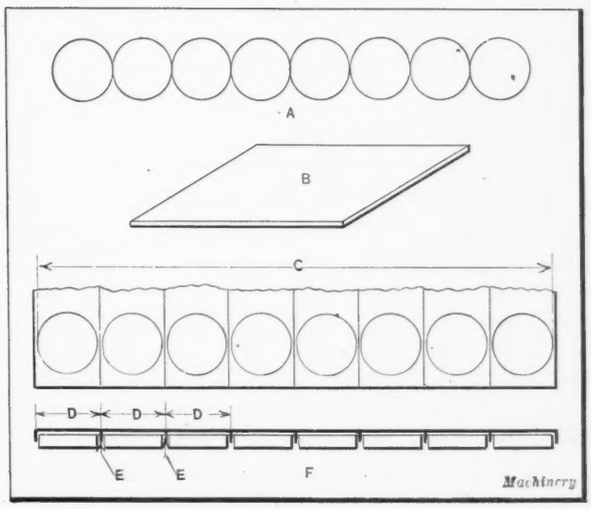

Fig. 2. Diagrams illustrating Problem in arranging Pieces before placing in Box

one or two pieces and feel satisfied that the remainder are of the same size. Under these conditions, a great deal of trouble might be caused by insufficient allowances which cause pieces to stick in the magazines or carriers.

Three different items must be handled: the tablets, the cardboard spacers, and the boxes. Each of these must be handled by separate units yet each must operate in such a way that it can be placed around or near a central assembling table. Just what the arrangement will be we cannot say at present, but by designing the units one at a time and considering the position of each during the design, we can proportion the parts so they will not interfere with each other. The principle of unit design must be followed, but the designer must keep in mind the fact that there are other units to consider beside the one on which he is at work.

Designing the Mechanism for Handling the Tablets

We need not now consider any devices used for straightening out the tablets, as previous articles have dealt with this problem. The pieces are to be handled in large quantities and would naturally be dumped on a conveyor which would incline upward and carry them to a distributing hopper where they would be separated so they would glide down eight chutes, as shown at *A* in Fig. 3. A shut-off mechanism, a diagram of which is shown at *B*, must be used. This device allows only six pieces to come through the chute at one time, the lower one resting against the trigger *C*.

Let us make a receiving drum revolving in the direction shown by the arrow *D* and stopping at six points in every revolution. Each stop brings eight carriers in line with the chutes, and the valve arrangement operates at the proper time. As the drum stops, one station is always in the position *E* opposite the receiving table on which the tablets are to be arranged. The enlarged section *W–Z* illustrates the arrangement of the guides *F*. In the center of each of these, a metal finger moves, and there is a hook on the end of it, as shown at *G*, so that each finger pulls out six pieces from the chute as required. The enlarged section at *X–Y* shows the finger strip at *H* and the construction of the clip at *K* which prevents the fingers from dropping down into the guides. A cross-bar *L* passes through eight of the fingers, as shown, and ties them all together, acting also as a sup-

port. As the drum reaches the station *E*, the slide *M* is in the position shown, and the bar *N* that connects eight of the fingers enters the jaws as shown. An enlarged detail of this mechanism is shown above, and a short description is necessary in order to make the operation clear:

The piece *M* is arranged to slide, as shown by the arrows, and when in the position illustrated, the gripping fingers *O* and *P* grasp the cross-bar *N*. The slide *M* is so timed that it lies in the position shown just before the revolving drum reaches the discharge position, so that the bar snaps into position between the fingers which are spring-mounted. As the slide recedes in the direction *Q*, it pulls with it eight finger strips, thereby discharging forty-eight pieces on the table, as shown by the dotted lines at *R*. The slide then immediately moves backward in the direction *S*, leaving the finger strips in their original position. As the drum rotates to the next position in the direction shown by the arrow *T*, the gripping fingers rise with it and gradually pull away from the cross-bar *N*, after which the fingers drop ready for the next magazine. A snap-catch at *U* prevents the finger strips from pulling out during the revolution of the drum. There are two slides *M* so arranged that they catch the bar *N* only at each end which leaves the center of the table free of all mechanisms which might interfere with other operations.

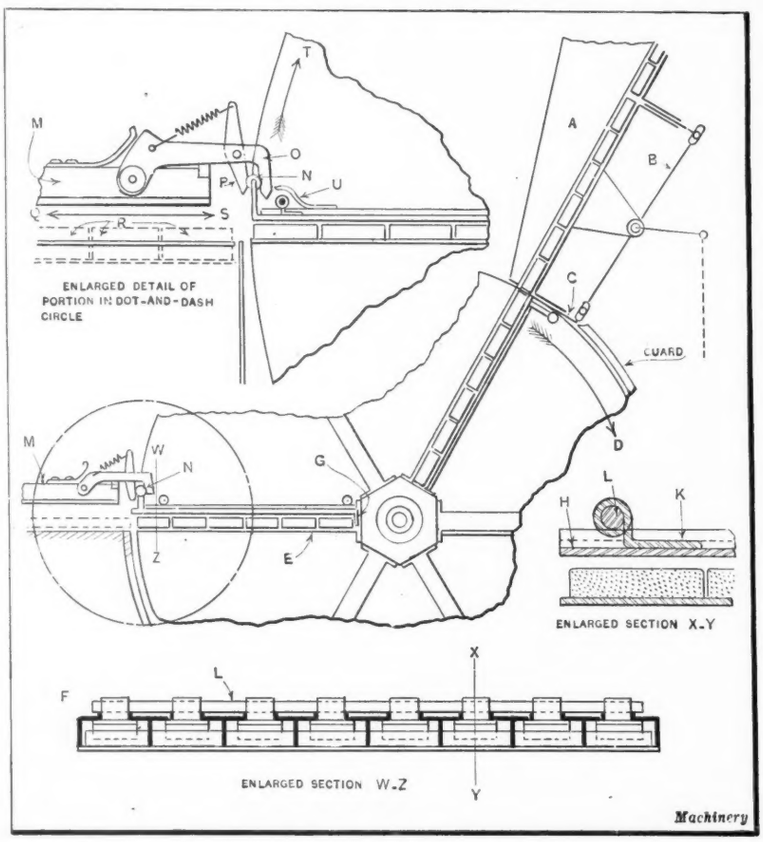

Fig. 3. Method of feeding and arranging Tablets

Several other methods of removing the pieces from the chutes are possible, one of these being by an angular discharge chute operated by gravity. The chutes would then need to be set at a sufficient slope to carry the pieces over to the receiving table. This method would not usually be found satisfactory because of rebound and possibility of breakage. It is generally better to use a positive mechanical movement rather than to depend upon springs or gravity. As we are depositing on the table not one layer but ten, the table on which the pieces are discharged must be arranged so that it will drop a sufficient amount to allow for the thickness of one layer of tablets and one cardboard at each stopping station of the drum. The simple mechanism used for this will be mentioned later.

Feeding the Cardboard Spacers

Our next problem is feeding the cardboard spacers and placing them in position over each layer after it is deposited on the table. There is likely to be some variation in the thickness of the material, and although this may not be more than 0.001 inch to 0.003 inch, under certain conditions even this variation might cause considerable trouble. Another thing that must be thought of is the fact that, in the manufacture, a number of thicknesses are usually cut at the same time, and the pressure of the cuts may cause the edges to turn over slightly, as shown at *A*, Fig. 4, so that two or three pieces will stick together and not separate easily. For this reason it is not advisable to place the pieces in a magazine without first disturbing their arrangement. Several hundred pieces may go through without trouble, while the next hundred may stick and clog the machine.

Assuming that the pieces have been separated (as can be easily done by spreading them), they can be placed in a magazine *C* with a weight *D* on top of them, if necessary, to make sure that they will feed readily. The bottom of the magazine is open at the front *E* and the rear *F*. The slide *G* is cut away at *H* to a depth a trifle less than the thickness of one piece, and the slide moves forward only to the position indicated by the dotted lines at *K*. This movement is sufficient to carry the cardboard between the feed-rolls *L* and *M*. The rolls are driven at a speed somewhat greater than the movement of the slide *G* so that they pick up the cardboard and shoot it forward over the tablets in the direction of the arrow *N* until it strikes the edge of the guard strips *O*, the nature of which will be mentioned later. Rolls *L* and *M* can be run either continuously or with an intermittent motion, but it is important that they should move rapidly enough to pull the piece away quickly from the slide *G* and give it sufficient impetus so that it will carry over to point *O*. Care must also be taken to avoid interference with the slide mechanism *P* used in feeding the tablets. It is a good idea, in designing units, to show either by dotted lines or red lines any points that are likely to approach close to the parts in process of design.

In the construction of the feed-rolls and their mounting, a few details may be of interest. These are shown on an enlarged scale at *Q*. In feeding paper, the rolls can be made of brass tubing, as shown at *R*, with a cast-iron bushing at *S* in which the shaft is pinned. The feed-rolls should be geared together, as shown at *T*, and the spacing of the shaft center distances should be sufficient to allow for variations in the thickness of the cardboard shown at *U*. The shafts are journaled in sliding boxes *V*, the upper one of which is made adjustable by means of a handwheel and screw. Instead of using the screw, it is possible to employ coil springs which will automatically compensate for variations in the thickness of the material. If desired, a coil spring can be placed between the end of the screw and the sliding box.

The trouble sometimes caused by the edges of the cardboard sticking together can be overcome in another way by making the magazine in angular form, as shown at *W*. When this is done the edges of the cardboard are never in line with each other, but always overlap slightly, the amount depending upon the thickness of the pieces and the angularity of the magazine. The method of feeding the cardboard is identical with that previously described.

The end view at *X* shows the support *Y* at the front end of the magazine. This provision is quite important, as it

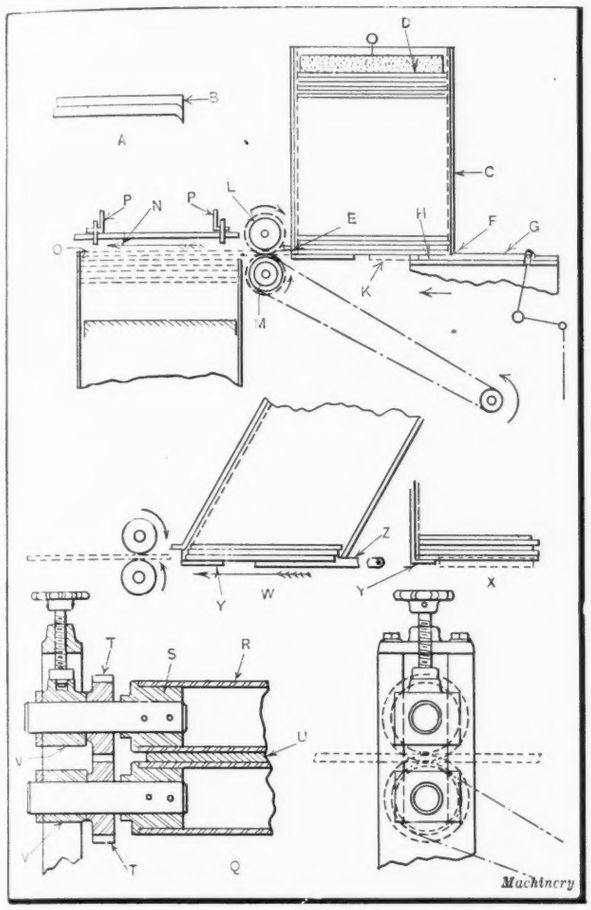

Fig. 4. Diagrams showing Method of feeding Cardboard Spacers

obviates the necessity of carrying the slide *Z* along under the entire bottom of the magazine. If very much heavier and thicker material were to be fed in the same way, it might be advisable to use rollers as a support at the point *Y*, in order to minimize the friction. In this case it is unnecessary, and would be more expensive.

In a previous article attention was called to the advisability or starting at the beginning when considering any problem. A case in point is this pasteboard feed mechanism. The cardboard (if not too heavy) could be purchased in the form of rolls, and if used thus it might be possible to feed it over the tablets and cut it off to the proper length at the same time. In order to illustrate this method, assume that we have a roll of cardboard as shown at *A* in Fig. 5. This passes under roll *B* over *C* and between *D* and *E*. The roll *E* is driven intermittently a given distance through gear *F* by any suitable mechanism. The shafts on which *D* and *E* revolve are provided with gears of the same diameter and pitch so that both are driven uniformly. The rolls *B* and *C* are not driven. Roll *D* should be adjustable in the direction indicated by the arrow *G* in order to give the tension required.

After leaving the two feed-rolls, the cardboard passes outward to point *H*, and stops. The knife *K* cuts it off at this point, and it falls as at *L*, being carried forward slightly to the position *M* by the inclination of the plate at *N*. The edges of the rolls should be provided with guards to prevent the cardboard from running to one side or the other. Also if the material is quite wide, the rolls should be made slightly smaller in diameter at the center, tapering to each end, so they will pinch more at the edges of the cardboard than in the middle. A variation of two or three thousandths inch is sufficient. There is always the possibility that the cardboard may curl at the end *H* or that it may be sufficiently out of alignment so that it will not fall truly over the tablets. Such a condition would cause considerable trouble, but it is possible to avoid it by allowing the cardboard to enter the side guides, as shown at *O* in the diagram at *P*. It is also supported by the swinging leaves *Q*, which prevent it from sagging. At the proper time the levers *R* pull the leaves down to position *S* and allow the cardboard to fall to point *T*. This is really a much better way to feed the board than the other example.

The edges of the piece should be guided at the point *U* up to the edge of the knife blade so that they will always pass between the blades properly. The roll *V* is held by a spring *W* against the rapidly diminishing supply roll *A* and prevents the cardboard from gathering up at point *X*. If a method like this is used, the solution of the pasteboard problem is considerably simplified, an additional advantage being that the piece can be fed into position over the work-table before the tablets are in place. Then, it can be dropped immediately, thus saving some time in the production.

We have now succeeded in feeding both tablets and spacers into position, and have only to provide the mechanism for lowering the table, feeding the boxes, and putting the tablets in place in the boxes. It is an easy matter to feed a number of square boxes into almost any given position, but how can we put the pieces into the box without spilling them? After considering the difficulty of putting the pieces into the box, we may turn about and decide to put the box over the pieces, which simplifies the proposition materially.

Method of Feeding and Discharging the Boxes

Fig. 6 illustrates, in diagram form, the method used for the entire operation of handling the box, placing it over the stack of tablets, and ejecting it ready for the attendant to remove it and put on the cover. The boxes are fed to a conveyor having cross-strips on it spaced far enough apart to allow clearance. The conveyor is operated by a stop-and-go mechanism, which feeds it just the distance between boxes each time it is required. The boxes travel in the direction shown by arrow *A* and stop at position *B*. The carrier *C* pushes the box over to the guides *D*, where it stops against the two adjustable points *E*. A section of the guide strips from *F* to *G* is hinged so that when turned it will allow the box to drop. The construction is clearly shown in the detail view at *H*. The carrier has the pushing head *C* mounted on a spring so that it "gives" a trifle when the box strikes against the stops located at *E*.

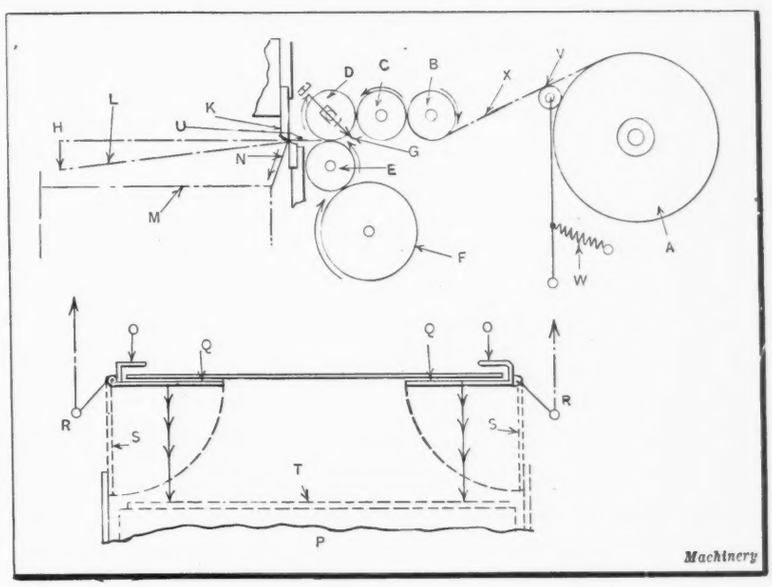

Fig. 5. Application of Roll Feed for Thin Cardboard

When the box is in position on the guides and against the stops, it is exactly over the stack of tablets on the table *K*. These are kept in regular form by the long steel strips *L*, two of which are against each side of the stack. These steel strips are very long and extend down through the guides shown; they are attached to an operating plate at *M*, by means of which they are moved up or down in unison as required. At the proper time, the long strips move up and pass inside the box, as shown by the dotted lines at *N* and also more clearly in the enlarged view at *O*. Moving downward, they release the spring hinges which allow the box to pass through until it rests over the stack of tablets at *P*.

The guide strips continue downward until just below the point *Q* where they stop. The table *K* on which the filled box rests is pivoted at *R* in bracket *S* which is fastened to the operating shaft *T*. This moves downward, and when the edge of the table strikes the stop *U*, it tilts over and

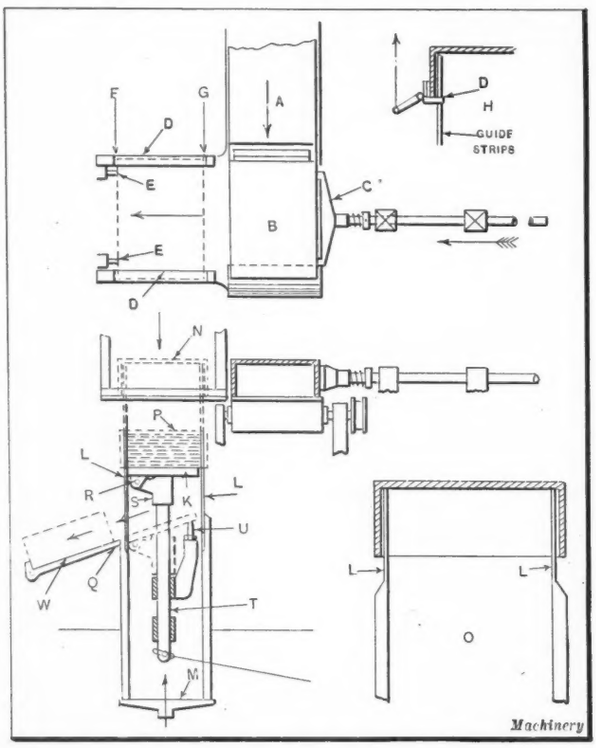

Fig. 6. Method of feeding and discharging Boxes of Tablets

the box slides out, as shown by the dotted lines. The attendant holds one hand on top of the box and turns the leaf over which leaves the box right side up ready for the cover.

The long movement of the vertical guide strips made it necessary to cut openings in the floor to allow for it. It would have been possible to use shorter strips and guide the box by the outside, but such a scheme might have caused trouble by the box disturbing the arrangement of the tablets. It was considered safest to use the finger arrangement described. It does not seem necessary to show the arrangement of the various units and their power applications, for it is with the construction of the units used that we are chiefly concerned.

The production obtained from this machine was not so great as originally expected, but the saving in hand labor was considerable. It took about twenty seconds to pack one box and deliver it, ready for the cover. Had it not been for the expense of construction, a much higher production could have been obtained by making ten groups of chutes and passing from one to the other of these in sequence, loading one layer at a time and putting on the box immediately after the last station. A somewhat different form of construction would have been required, but the extra production obtained would not be warranted by the additional cost of manufacture. The machine took the place of six girls and one man, and the cost of designing and building was about $7500. It paid for itself in less than two years.

Every unit in the design was worked out in elementary form by means of wooden and tin models, no one of which cost over $100 to make, although considerable time was spent in experimenting and changing the models to obtain better results. Pasteboard boxes of small size were used for the box-feeding model, and although these were not so heavy, in proportion, as the wooden boxes, they came through the test without sticking. So, also, in making the feeding device for the tablets, fiber washers such as those used for packing water faucets, were placed in tin chutes and fed by means of a wooden slide, which hooked over the end of a bar in the same way as the finished machine. The model used for feeding the cardboard was also made small, and the feeding rolls were operated by a hand-crank, while the slide was also pushed forward by hand.

In each of these models, a principle was demonstrated, and when that principle had been proved correct, the designer went to work on the machine itself. It is the writer's belief that by no other method can certain results be assured. Seldom does any machine that has been worked out entirely on paper, give perfect satisfaction when tested.

* * *

INDUSTRIAL STANDARDIZATION IN 1924

In a report covering developments in industrial standardization during 1924, the American Engineering Standards Committee states that in all, about seventy standards have been approved by the committee, and one hundred others are under way. Of these, thirty-two have to do with civil engineering, and the building trades; twenty-six with mechanical engineering; fifteen with electrical engineering; four with automotive subjects; eleven with transport; one with ships and their machinery; fourteen with ferrous metals; fifteen with non-ferrous metals; twelve with chemical subjects; two with textiles; sixteen with mining; five with the wood industry; one with the paper and pulp industry; and eleven projects with topics of a miscellaneous or general character.

The most important piece of work completed in the mechanical field during 1924 was the promulgation of the standard for screw threads, a subject which touches practically every industry. This was worked out in cooperation with the National Screw Thread Commission. Good progress has been made in two other far-reaching subjects—gages and systems of gaging, and pipe flanges and fittings. Parts of the work on both of these subjects are now nearly ready and will be issued soon.

Work on dimensions and tolerances for nuts and bolts is also well advanced. At an informal conference of representatives of the American, Czecho-Slovakian and German committees, it was recommended that there be held a general international conference looking toward international agreement, so that there may be international interchangeability in regard to wrenches, nuts, and bolt heads.

In the field of industrial safety, substantial progress has been made on a program of some forty codes, most of which are applicable to factories. Thirteen of these have been completed, and work on half the rest is well advanced.

The Federal Specifications Board has now adopted nearly three hundred specifications. These are used as a basis of purchase throughout the Federal government. The American Engineering Standards Committee has continued its cooperation in this work, and during the year has circulated more than one hundred of these specifications for criticism, in order to determine their acceptability in industry, before official adoption by the government.

The third year of the work of Mr. Hoover's Division of Simplified Practice has shown extensive development. In all, twenty-six simplifications have already been carried through, ten others are in the final stages, and forty-five surveys are now under way. Two hundred industrial groups are cooperating in the various projects.

MACHINING EVENLY SPACED POCKETS IN FORMING DIE

By DANIEL F. MORIARTY

One of the most interesting jobs that the writer has seen done in a lathe was the machining of the piece shown at *A*, Fig. 2. This piece is a cylindrical block of steel having on each of the flat sides a circular row of pockets of spherical form, and a central hole for a fillister-head screw. It is used as a finish-forming die for the ring shown in Fig. 1. As indicated by the section *X–X*, this ring has a series of evenly spaced spherical depressions or pockets in it. At *B*, Fig. 2, is shown the master plate employed in machining the pockets in piece *A*.

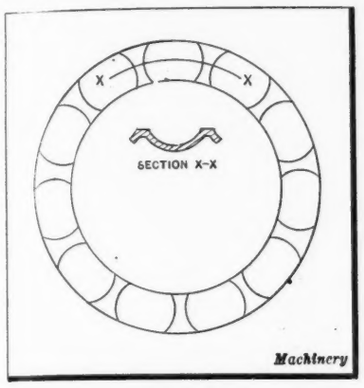

Fig. 1. Ring formed on Die shown at A, Fig. 2

After facing one side of the steel blank from which piece *A* is made, it is soldered securely to one side of the master plate *B*, as indicated at *S*, Fig. 3. The master plate is then clamped to the faceplate of the lathe with the pin *P* located in the central hole. The blank is next finished to the required thickness and diameter, the hole for the screw at the center of the die being reamed and counterbored. The master plate *B*, with the work secured to it, is next removed from the faceplate and re-located thereon with the pin *P* inserted in one of the evenly spaced holes like the one shown at *C*, Fig. 2. This method of locating the work is used in drilling each of the pockets. The drilling is done with a large center drill to within about 0.005 inch of the finished depth, using the dial indicator to measure the depth in the manner indicated in the view at the lower right-hand corner of Fig. 3.

After all the pockets have been drilled, they are roughed out with a tool conforming to the outline of the reamer shown in the upper right-hand corner of Fig. 3, which is used to finish the pockets after they have been roughed out. After reaming one of the pockets to the finished depth, as determined by the micrometer depth gage, the dial indicator is set to zero, so that it will show when the remaining pockets have been machined to the required depth. A cooling lubricant is used during the reaming operations as well as when roughing out the pockets. The required finish is obtained by polishing with emery cloth. After the pockets and one side of the die have been completed, the die is removed from the master plate, turned over, and again soldered to the master plate. The other set of pockets is then machined in the same manner as the first set.

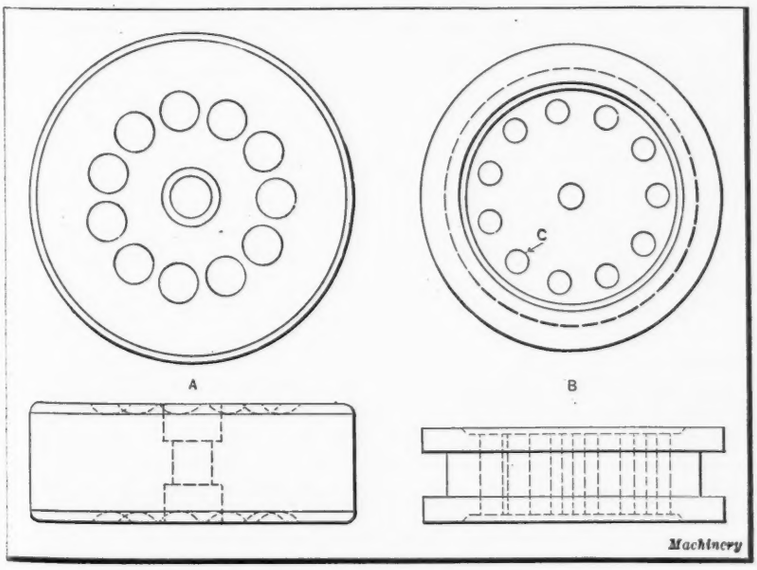

Fig. 2. Die and Master Plate used in locating Pockets in Die

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COAL MINING MACHINERY

For some years past, the demand for coal-mining machinery has been limited. There are several reasons for this. In the first place, an over-development of coal-mining facilities has resulted in a surplus of coal-mining machinery installed at the mines. On account of this, even the repair part business, which is usually a big item in this field, has fallen off, because when repair parts are needed at many mines, such machines as are standing idle are robbed for parts to be used on those machines that are operated. There is no likelihood of a change in this condition for at least a year to come. Gradually, however, the smaller producers will go out of business or be absorbed by the larger mines, and in that way a more normal and healthy condition will obtain in this field. Another reason for hesitancy in the buying of coal-mining equipment is that the methods by which coal is mined are somewhat unsettled. There is a considerable effort being made to develop new methods, but no definite development has yet taken place. There is great need for coal-loading machinery to replace manual labor, but as this type of machinery has not yet been developed to a point where it is considered successful from every point of view, buying is being deferred until the coal-mining operators are satisfied as to the success of the new methods introduced. When a successful coal-loading machine has been developed, there will be a great and immediate demand for this type of equipment.

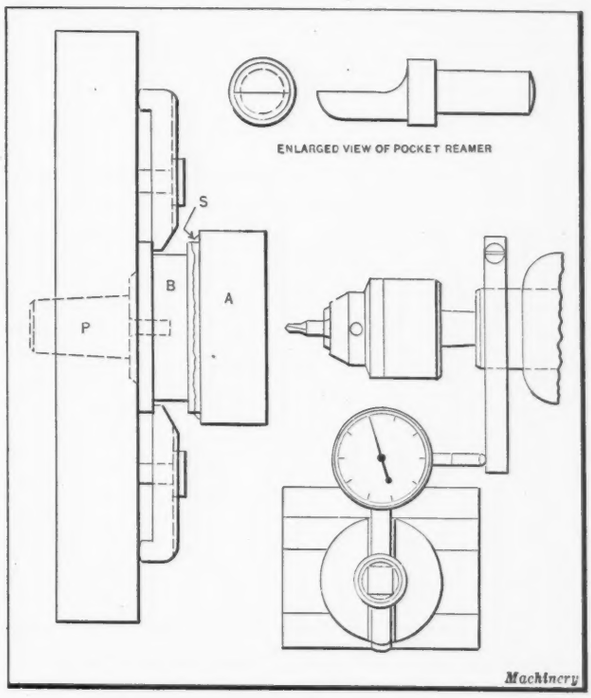

Fig. 3. Equipment used in machining Pockets in Die A, Fig. 2

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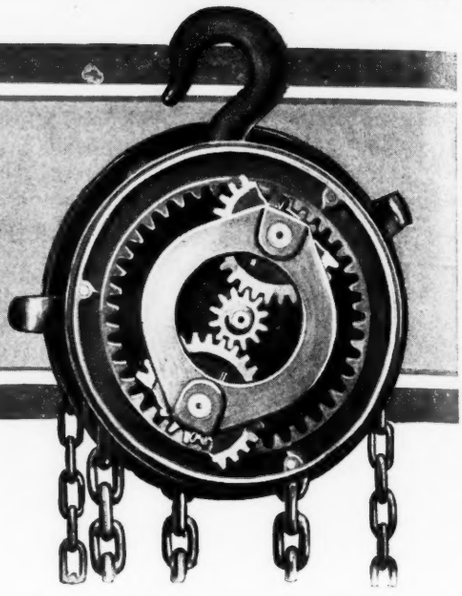
The greatest freight traffic for any one month in history was carried by the railroads in October, 1924.

Planetary Gearing

By FRANKLIN DeRONDE FURMAN
Professor of Mechanism and Machine Design
at Stevens Institute of Technology



Marine Reversing Gears as Examples of the Planetary Form of Construction—Ford Transmission Problems—Seventh Article

THE subject of bevel wheels in planetary gear mechanisms was covered in the preceding article of this series. A simple planetary gear problem comprising three bevel wheels was used to point out a different method of projection of velocity lines in solutions by the graphical method from that used in spur gear problems. The analytical method, as used in spur gearing, was shown to apply to bevel gearing without any modification in all cases where the driver and follower were sun wheels. The well-known Humpage planetary gear was then used as a general problem, and solutions were made by the graphical and analytical methods. The case in which the planet bevel wheel is the follower was next considered. Finally, the case where sun and planet bevel wheels are not of the same size, was considered. In such problems, the angles of pitch cones do not have the same ratio as the angular velocity ratio which they produce. The method of allowing for this in the graphical solution was explained. Article 6 concluded the presentation of the fundamentals of planetary gearing, with elementary problems introduced throughout the series thus far to exemplify these basic fundamentals. The notation follows:

N = number of turns of driver to one of follower or driven member;
N' = number of turns of follower to one of driver;
N_1 = number of turns of driver to one complete revolution of planet wheel axis;
N_2 = number of turns of follower to one complete revolution of planet wheel axis;
D = diameter of pitch circle of driver, if driver is a toothed wheel; (The driver or the follower may be the "train arm," and not one of the toothed wheels, according to the data of a problem.)
D_1 = diameter of pitch circle of follower, if follower is a toothed wheel;
D_2 = diameter of pitch circle of the fixed wheel;
D_3, D_4, etc., = diameters of pitch circles of planetary wheels;
T = number of teeth on driver, if driver is a toothed wheel;
T_1 = number of teeth on follower, if follower is a toothed wheel;
T_2 = number of teeth on the fixed wheel; and
T_3, T_4, etc., = number of teeth on the planetary wheels.

The fundamental principles of planetary gearing have been given with a fair range of ordinary application in the problems in the preceding articles. These principles are sufficient to solve any planetary combination that may arise, so far as the elementary planetary action is concerned. Planetary mechanisms may be found, however, in which (a) the planetary form of construction of the gear is employed, even though the device may never be used in planetary action; (b) the principles of planetary action are compounded or multiplied; (c) the planetary analysis must be combined with a general velocity diagram analysis; or (d) the bevel wheel with its distinctive characteristic must be considered.

Marine Reversing Gear

A marine reversing gear that has the planetary form of construction but that is not used as a planetary gear when running ahead or astern is illustrated in Fig. 29. This design affords a good example of the apparently complicated structure sometimes necessary to take care of practical details in housing a simple elementary principle, especially where that principle is made to serve in giving various results under changing operating conditions. The contrast between the complex mechanical construction and the simple graphical construction necessary to solve the problems involved in this mechanism is shown by comparing Figs. 29 and 30. The former illustration shows the practical construction, and the latter the complete graphical solution of the problems involved in running ahead and astern.

This marine reversing gear is constructed and operated as follows: The engine shaft is shown at A, Fig. 29, and the propeller shaft at P. A spur wheel B is keyed to A, and engages pinions D of which there are four to distribute the power transmitted, although only two of the four pinions are shown. (Either two, three, four, or six planet wheels are always used in all types of planetary gears to divide and distribute tooth pressure and to balance the eccentric weight that would be introduced if only one planet wheel were used). Planet wheel pins C are fastened in the disk F which turns freely on the engine shaft A. Disk F corresponds with the train arm of previous problems. An internal gear wheel E engages the four pinions D, and is keyed to the propeller shaft. It is also fastened to the expander H as shown, and this expander is keyed to the propeller shaft. Drum G is free to turn on the hub of the internal gear E and is firmly bolted to F. When the two expander arms L are pressed out by the cone N, the expander rim H, which is split longitudinally, grips the drum G and holds it firmly by friction. A cross-shaft O, operated by hand-lever R, is keyed to crank Q, which is shown in its central or neutral position.

The operation of the gear is as follows: To run ahead, Q is thrown to Q_1, pressing out the expander rim H so that it will firmly grip the drum G by friction, thus making all the parts P, H, G, E, F, C, D, B, and A integral, and causing them to act as one solid piece. A question that might be asked here is: Why should all the parts act as one solid piece when pinions D are not keyed to pins C and when they appear to be perfectly free to turn on these pins? For those who may need assistance in answering this question, it is pointed out that the parts E and F are fixed with respect

to each other in forward running; therefore the outer teeth of pinions D that are in mesh with the teeth of the internal gear wheel E, and also the centers of the pinions are being rotated about the main center line XX of the gear with the same angular velocity, because E and F are rigidly connected. It follows that the pinions cannot turn on their pins under these conditions. This throws the entire load on the teeth of the wheel B that are in engagement with the pinions. It is always the same teeth of B that are transmitting the load at the radius XX–S while the engine is running forward. In this connection it must be kept in mind that the whole transmission load is divided in this case between four sets of gears, two of which are shown at D.

To reverse the propeller, the hand-lever is thrown to the left, thus moving the crank to Q_2, releasing the pressure on the expander arms L, and so disengaging absolutely the surfaces between H and G. At the same time that the crank is thrown to Q_2 a link connecting it with the reverse band M is drawn over, and band M is firmly clamped to drum G by frictional contact. (The connecting link between Q_2 and M is not shown). Band M is fastened to the frame of the engine, and so is not permitted to turn. With G thus held stationary, F and C are also held stationary. Thus it is that when the driving gear B now rotates, it rotates pinions D on fixed pins C. Pinions D then transmit the rotation to E and to the propeller shaft P in the opposite direction, it being remembered that H is now entirely free from G.

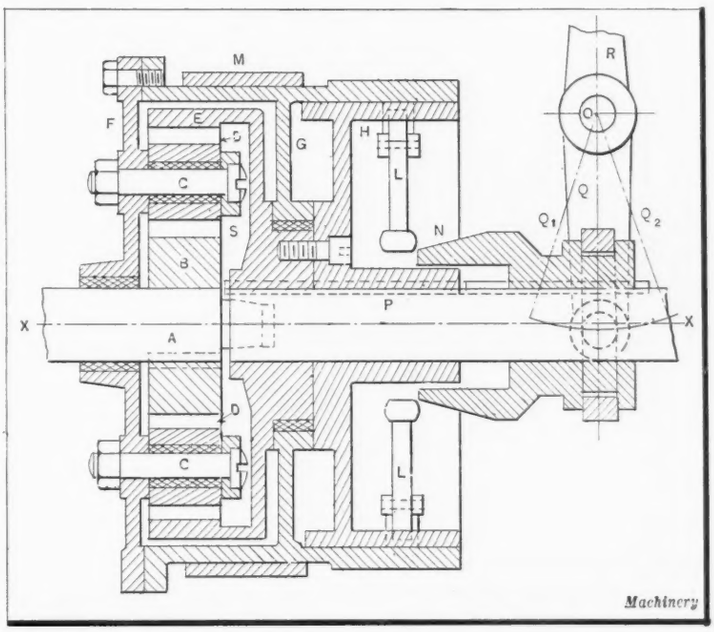


Fig. 29. Diagrammatical Arrangement of a Marine Reversing Gear

Graphical Analysis of Reversing Gear Action

A graphical analysis of the action of the marine reversing gear just described is readily made. For running ahead, no construction seems necessary, but if desired, the velocity lines may be shown as in Fig. 30, where they are represented by dash lines; MA is the radius of the pitch circle of wheel B, Fig. 29; MC is the radial distance from the center line XX to the center line of pins C; and MP is the radius of the pitch circle of the internal gear wheel E, Fig. 29. Then if AB (Fig. 30) represents the linear velocity of the point A on the pitch circle of B, it also represents the velocity of the point A of the pinion AP. Since P and C are immovable with respect to each other, because of the nature of the mechanism as previously described, and since point A of the pinion is also immovable with respect to C and P, it follows that if A has a velocity AB, C must have a velocity CG, and P must have a velocity PH, all proportional to their distances from the center of rotation. Then since angular velocity is linear velocity divided by radius, the angular velocity V of the driving shaft $= \frac{AB}{MA}$, and the angular velocity V' of the follower shaft $= \frac{PH}{MP} = \frac{CG}{MC} = \frac{AB}{MA}$; therefore

$$\frac{V}{V'} = \frac{AB}{MA} \times \frac{MA}{AB} = 1$$

or, in other words, the angular velocity of the driver and follower shafts is the same.

Problem 20—The marine reversing mechanism illustrated in Fig. 29 has 36 teeth on the crankshaft drive gear B, 12 teeth on each of the four planetary pinions D, D_1, etc., and 60 teeth on the internal gear wheel E. All teeth are cut on the same pitch. What will be the angular velocity of the engine shaft relative to the propeller shaft in reverse?

The graphical solution of Problem 20 is illustrated in Fig. 30, where AB represents the linear velocity of a point on the pitch circle of the driving gear. Since the pins C of the "planetary" pinions are held stationary in reverse running, the pinions transmit this velocity to PE at the pitch circle of the internal gear which is keyed to the propeller shaft. This latter velocity, it will be noted, is at the radius PM. When it is reduced to the radius AM, it becomes a measure of angular velocity of the follower shaft, and is comparable to the angular velocity of the engine shaft. This reduced velocity is $-AF$. The angular velocity, then, of the engine shaft relative to the propeller shaft is $\frac{AB}{-AF}$. If these lengths are measured, they are found to be $\frac{5}{-3}$. In other words, the engine shaft makes $\frac{5}{3}$ turns clockwise while the propeller shaft makes one turn counter-clockwise. The minus sign is introduced before AF and before the 3 because AF is found to be in an opposite direction to AB. Stated another way, the propeller shaft makes 0.6 of a turn to one turn of the engine shaft.

The mathematical solution consists simply in writing the formula

$$N = \frac{-D_1}{-D_2} \times \frac{-D_3}{+D} =$$

$$\frac{-60}{-12} \times \frac{-12}{+36} = -\frac{5}{3},$$

or $N' = -0.6$. In this problem there is no planetary action and consequently the equation for N is written exactly as it would be for a simple train of gears having fixed centers. The minus sign is placed in front of wheels that have counter-clockwise motion.

Reversing Gear Having Pairs of Planet Wheels Arranged as Shown in Fig. 31—Problem 21

A marine reversing gear will now be considered, that differs somewhat in mechanical construction from any simple planetary mechanism referred to thus far for the reversal of motion. The purpose of this special gear is to give reverse running with unusually high propeller speeds. The essential arrangement of the gears is illustrated in Fig. 31. It will be noted that the outstanding feature in the mechanical construction lies in the fact that the two essential planet wheels T_3 and T_4 are separate and distinct wheels mounted in the same plane and gearing with each other, instead of being mounted on the same shaft. This form of construction will be analyzed in the following problem.

Problem 21—A disk represented by the train arm R in Fig. 31 is keyed to the driving shaft. The disk carries several pairs of planet spur wheels, one wheel of each pair gearing with the follower sun wheel T_1 which has 32 teeth, and the other one with a fixed internal wheel T_2 which has 60 teeth. There are, in practice, three or more pairs of the small 12-toothed planet wheels mounted on the driver disk

to give strength and balance, but they are not all essential to the graphical or analytical solutions of the problem, and therefore all but one pair are omitted in Fig. 31. What will be the rate of turning of the propeller shaft compared with the engine shaft?

Graphical Solution of Problem 21

The graphical solution of Problem 21 is shown in Fig. 31. The new feature in the graphical analysis of this problem is that each of the two essential planet wheels T_3 and T_4 must have its own instantaneous axis. In previous problems, the two or more essential planet wheels have been mounted together on a single pin, and therefore they have all had the same instantaneous axis, which in all cases where a fixed wheel was used, has been at the point of tangency of a planet wheel and the fixed wheel. In the two cases where the so-called fixed wheel moved, a more general case was involved and the instantaneous axis was found accordingly. No new principles are involved in the present problem, but it is a still more general case than any thus far considered. It may be well to state again the definition of instantaneous axis; it is that point, within or without the object, about which every point in the object has the same *absolute* angular velocity, or rate of turning, at any given phase or instant. If, then, the resultant directions of motions of two points of a moving object are known for any phase, the center of motion, or instantaneous axis, for that phase of the object, may be found by simply drawing from each of the moving points, straight lines perpendicular to the directions of motions of these points. The intersection of these perpendicular lines will be the instantaneous axis. The graphical solution of the problem is greatly simplified by noting that only the directions, and not the magnitudes, of the motions are essential in the definitions just given.

Applying the foregoing definitions, let AB represent the angular velocity of the driving disk which carries the planet wheel pin A. Then the center of the planet wheel pin O has the same angular velocity about M, because it is fastened in the same disk, and the planet wheel T_3 is compelled to roll on the internal gear wheel T_2, which is fixed. Consequently point C of the planet wheel T_3 is at rest, at the phase shown, and point G of this planet wheel has a resultant motion about C in the direction GH perpendicular to CG. Since the tangent point G of the pitch circle of the planet wheel T_4 is in non-sliding contact with the pitch circle of wheel T_3 (because of the gear teeth), the point G of wheel T_4 must also have an absolute or resultant motion in the direction GH. The center A of the planet wheel T_4 has a resultant direction of motion AB. The resultant motions GH and AB of two points of the planet wheel T_4 are now known. Applying the definition given in the foregoing for finding the instantaneous axis, the lines GC_1 and AC_1 are drawn perpendicular to GH and AB, respectively, and the intersecting point C_1 is the instantaneous axis of the wheel T_4.

Since every point in the wheel T_4 must have the same angular velocity about the instantaneous axis, the point P will have a linear velocity PE found by drawing the straight line BC_1E. The line PE also represents the linear velocity of P on the follower wheel T_1, because, again, the pitch circles of gear wheels are in non-sliding contact. If PE is the linear velocity of T_1 at radius MP, the linear velocity at radius MA, the unit measuring radius at which AB was taken, will be AF and $\frac{-AF}{+AB} = N' =$ the number of turns of follower to one of driver, the directions being opposite because the initial and final velocity lines fall in opposite directions. The plus sign indicates clockwise direction of rotation, and the minus, counter-clockwise direction.

If the graphical construction is carefully made and lines AF and AB measure 7 inches and 8 inches, respectively, $N' = -\frac{7}{8}$; hence the propeller shaft in Problem 21 makes $\frac{7}{8}$ of a turn in one direction while the engine shaft makes one full turn in the other direction.

Analytical Solution of Problem 21

The analytical solution of Problem 21 is similar in principle to preceding problems, and, briefly, is as follows: Turning the entire mechanism in a clockwise direction once about M, we have one turn of the driving disk and one turn of the follower T_1; and consequently $N' = 1$, which means that the follower T_1 is turned once while the driver turns once. Holding the turning centers M, A, and O stationary and turning back the fixed wheel T_2, wheel T_3 turns in a counter-clockwise direction, wheel T_4 clockwise, and wheel T_1 counter-clockwise. The formula is now developed to read $N' = 1-$. When T_2 is turned back one full turn, T_3 is turned $\frac{T_2}{T_3}$ times; one turn of T_3 turns T_4, $\frac{T_3}{T_4}$ times; and finally one turn of T_4 turns T_1, $\frac{T_4}{T_1}$ times. Combining these, it follows that one turn of T_2 turns T_1, $\frac{T_2}{T_3} \times \frac{T_3}{T_4} \times \frac{T_4}{T_1}$ times. The formula is now developed to read $N' = 1 - \frac{T_2}{T_3} \times \frac{T_3}{T_4} \times \frac{T_4}{T_1}$. Substituting the values for T_2, T_3, T_4, and T_1 given in the data,

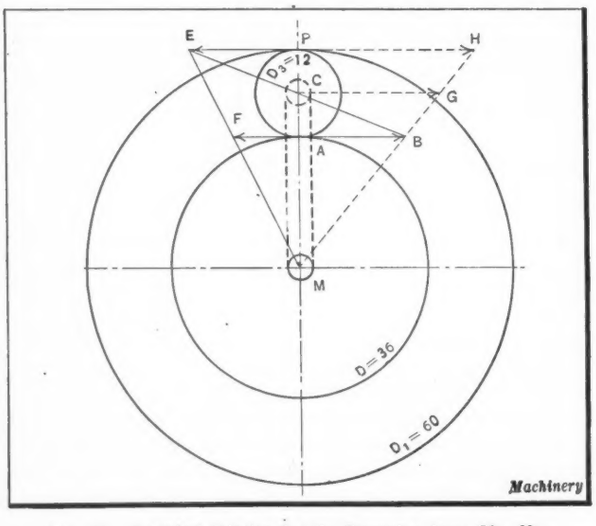


Fig. 30. Graphical Solution for the Reversing Gear, Fig. 29—Problem 20

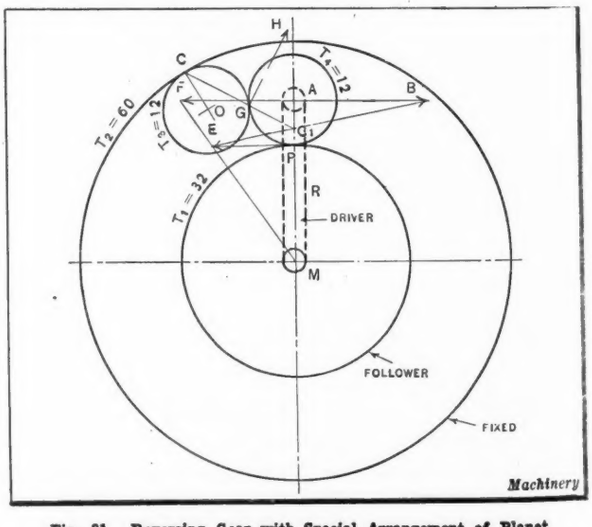


Fig. 31. Reversing Gear with Special Arrangement of Planet Wheels—Problem 21

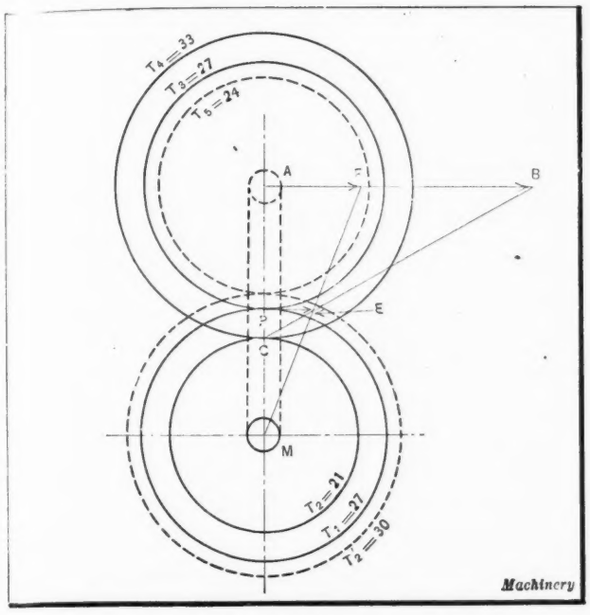


Fig. 32. Graphical Solution for Ford Planetary Gear in Low Speed—Problem 22

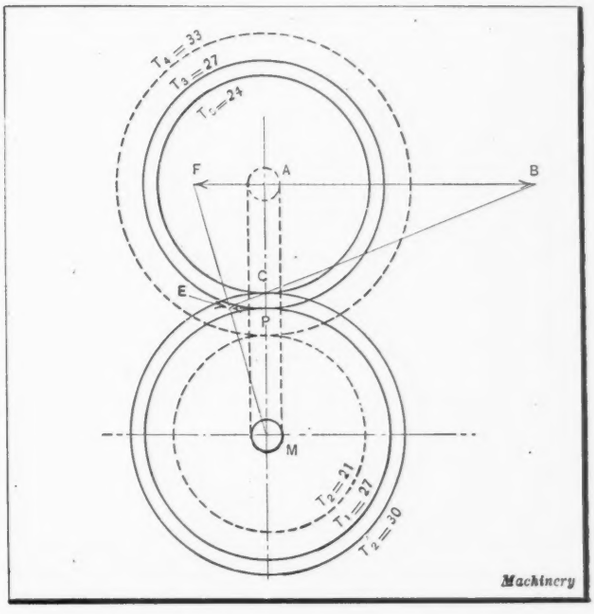


Fig. 33. Graphical Solution for Reverse Movement of Ford Planetary Gears—Problem 22

$$N' = 1 - \frac{60}{12} \times \frac{12}{12} \times \frac{12}{32} = 1 - \frac{15}{8} = -\frac{7}{8}$$

Hence, while the engine shaft is making one turn, the propeller shaft to which the toothed wheel T_1 is keyed is making $\frac{7}{8}$ of a turn in the opposite direction.

Ford Planetary Transmission Gear—Problem 22

Problem 22—In the Ford planetary transmission gear there are six essential gears with numbers of teeth as follows (see Fig. 32): Sun wheel $T_1 = 27$, gearing with planetary wheel $T_3 = 27$; $T_2 = 21$, gearing with $T_4 = 33$; and $T'_2 = 30$, gearing with $T_5 = 24$. The train arm carrying the pin or stud for the planetary wheels happens to be the flywheel in this case, and is the active driver in all the engine-driving planetary actions. In high-speed gear, the planetary gears are locked in two different places to firm connections to the engine shaft, and consequently they revolve as a whole with the engine shaft and there is no planetary action. All parts of the mechanism turn as one solid piece about the engine center line, and the follower or "drive" shaft has the same speed as the engine shaft. In low-speed forward gear, T_2 is held stationary and T'_2 is allowed to run idle so as to have no effect whatever on the active power transmission. In backward running, or reverse gear, T'_2 is held stationary and T_2 is allowed to run idle. What will be the relative speeds of the engine and follower shafts in running (a) low speed and (b) in reverse? Solve by the graphical and analytical methods.

The graphical solution for the planetary action in low speed forward is illustrated in Fig. 32. The wheel T'_2 with 30 teeth is running idle, and consequently it and its mating wheel T_5 have no bearing on the solution. These wheels are, therefore, indicated by dash lines. This leaves the solution dealing with low-speed gear as consisting of only four essential wheels, and the problem is identical with Problem 7 in the third article of this series. Therefore only a brief review of the explanation will be given here, as follows: AB represents the revolutions per minute of the engine shaft and of the flywheel stud which carries the planet wheels; AB may also represent the peripheral linear velocity of the planet wheel stud, as well as the linear velocity of the center point A of the planet wheel mass. Since the planet wheel T_4 is held stationary at the point C by the teeth on the wheel T_3, which is held stationary, the point P on the planet wheel mass will have a linear velocity PE. But the point P is a point on the pitch circle of the planet wheel T_3 which drives the follower wheel T_1. Therefore, the follower wheel has a peripheral linear velocity of PE at the pitch circle, and a linear velocity of AF at a radial distance MA.

Since AB is the linear velocity of a point on the driver, and AF is the linear velocity of a point on the follower, and both are at the same radial distance, these two values may be taken as a relative measure of angular velocities, or revolutions per minute; therefore, it is only necessary to measure the lengths AB and AF, as the number of revolutions per minute of the driver to one of the follower is as AB to AF, or $N = \frac{AB}{AF}$. If AB measures 10, and AF, 3.6, $N = \frac{10}{3.6}$ approximately, or the engine shaft makes about 2.77 turns to one turn of the follower shaft. The graphical method cannot give an exact answer, in general, but it is the simplest method to understand and affords a very close check on the analytical method, which gives exact results, although it is much more difficult to master.

Analytical Solution of Problem 22

The analytical method of solving Problem 22 is identical with that used in connection with Problem 7 of Article 3. Briefly, the solution is as follows: Consider all wheels locked together, and then turn the entire mechanism, Fig. 32, once in a clockwise direction around M. Then the driver (train arm) and the follower T_1 have each turned once, and $N' = 1$; that is, the number of turns of follower per one of driver is 1. Since all the wheels were locked together, the fixed wheel T_2 has had one full turn, which it should not have, and it is now turned back counter-clockwise a full turn, the planet wheel pin remaining stationary. As T_2 is turned back counter-clockwise, it turns T_4 and T_3 clockwise, and T_3 turns T_1 counter-clockwise, or in a direction backward from that which it had when it was given one full turn. Therefore, in turning T_2 back, T_1 also goes back, and $N' = 1 -$; in other words the turning back of T_2 will cause T_1 to make somewhat less than one full turn. The amount that it will be lessened is found by considering that as T_2 turns once, it will turn T_4 a fraction of a turn represented by $\frac{T_2}{T_4}$. The planet wheel T_4 is rigid with T_3, so that one turn of T_4 produces one turn of T_3. For each turn of T_3, T_1 is turned a number of times represented by $\frac{T_3}{T_1}$. Therefore, the full

equation for the analytical method of finding the number of turns of the follower per one of the driver is:

$$N' = 1 - \frac{T_2}{T_4} \times \frac{T_3}{T_1}$$

Since T represents the number of teeth on each wheel,

$$N' = 1 - \frac{21}{33} \times \frac{27}{27} = \frac{4}{11}$$

or, in other words, the follower shaft makes $\frac{4}{11}$ of a turn for each turn of the engine shaft when the car is running in low gear. Stated inversely, $N = \frac{11}{4} = 2\frac{3}{4}$, or the engine shaft makes $2\frac{3}{4}$ turns for each turn of the follower shaft.

Reverse Action of Transmission

The graphical solution for the Ford planetary action when in reverse gear (Problem 22) is illustrated in Fig. 33. The explanation of the principles involved is the same as for the low-speed solution previously given. Therefore, only the characteristic features of the reverse action will be pointed out. The sun wheel T_2 is allowed to run idle, and therefore this wheel, and T_4 which gears with it, are shown in dash lines, as they do not enter into the solution of the problem. AB represents the engine driving velocity, the same as for low gear. The fulcrum for the planet wheel T_5 is at C, since T'_2 is held stationary. Therefore the point P on the planet wheel mass will move in the direction PE opposite to AB; PE will also be the linear velocity of the pitch line of the follower T_1, and the velocity at the radius MA will be AF. Directions to the right of MA denote clockwise direction of turning, and are represented by the plus sign, which is generally understood to apply when there is no other sign written in. Directions to the left denote counter-clockwise direction of turning, and are represented by the minus sign. Then, from the diagram the number of turns N of the driver per one of the follower equals $\frac{AB}{-AF}$. Scaling the distances AB and AF, $N = \frac{10}{-2.5} = -4$, or the engine shaft makes four turns in one direction while the follower shaft makes one turn in the opposite direction.

The analytical solution for the reverse action of the planetary gear is similar to that given for the low gear problem. It should therefore be necessary only to write the equation for the reverse action as follows:

$$N' = 1 - \frac{T'_2}{T_5} \times \frac{T_3}{T_1} = 1 - \frac{30}{24} \times \frac{27}{27} = -\frac{1}{4}$$

The number of turns of the follower per one turn of the driver is $\frac{1}{4}$, and the direction is opposite to that of the driver. Expressed inversely, $N = -\frac{4}{1}$, or the engine shaft makes four turns clockwise while the follower shaft makes one turn counter-clockwise.

* * *

American exports of metal-working machinery to Italy increased approximately 75 per cent in 1923 (the last year for which complete statistics are available) as compared with 1922. The particular classes of metal-working machinery that showed increases were drilling and boring machines, milling machines, grinding machines, foundry equipment, and molding machines. As an example of how the European market is able to supply its own needs in such machine tools as lathes, for example, it may be mentioned that the total exports of lathes to Italy in 1923 were valued at $136—apparently just one lathe, and a small one at that, having been exported.

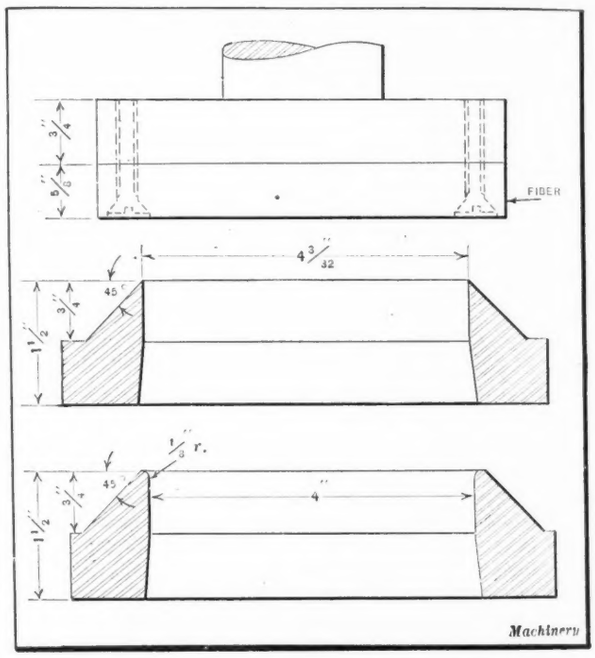
DIE FOR BLANKING FIBER

By CHARLES KUGLER

Some time ago the writer was confronted with the problem of making a die for punching or blanking pieces 4 inches square from hard, black fiber sheets ⅝ inch thick. After spending considerable money for the construction of dies of the type used for sheet metal without obtaining satisfactory results, the manufacturers of the fiber were consulted. At their suggestion a punch like that shown in the upper view of the illustration and a die similar to the one shown beneath the punch, were made up.

The length of the cutting edge on each of the four sides of the die was 4 inches, instead of 4 3/32 inches as indicated. It was suggested that the fiber be heated to about 160 degrees F. Better results were obtained with this equipment than had been secured with any of the sheet-metal types of punches, but the product was still unsatisfactory.

The manufacturers of the fiber next suggested that two dies be employed, the first one to be made as shown in the



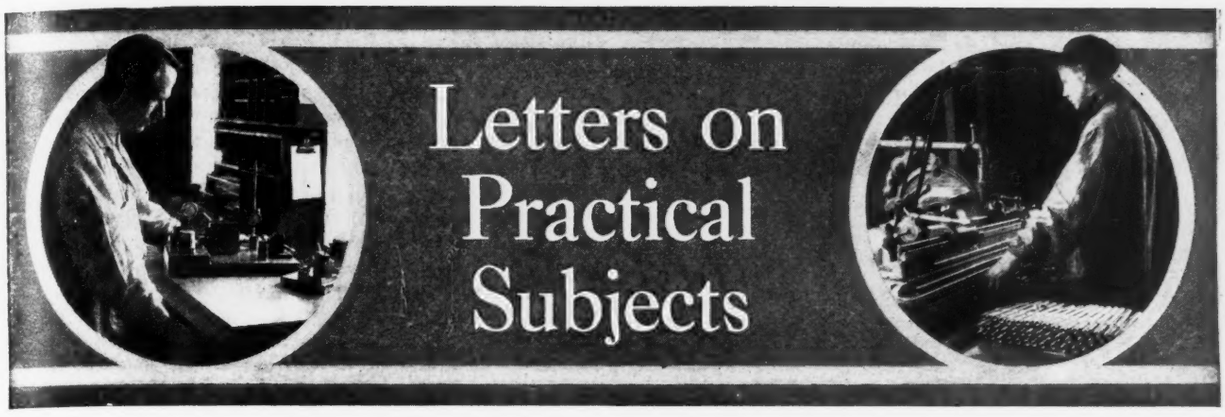
Punch and Dies used in blanking and sizing Fiber

second view from the top, and the second die as shown in the view at the bottom of the illustration. It will be noted that the punch has a flat fiber facing secured to it by means of flat-head machine screws and that the first or blanking die is 3/32 inch larger than the size specified for the square blank.

It will be evident that the punch does not enter the die, but presses the stock down on the cutting edge until the blank is severed from the sheet stock. The blank, thus produced, had rough uneven edges and was slightly over size. By passing the blank through the die shown in the lower view of the illustration these defects were remedied, and a good smooth blank of the required size obtained. When using these dies, the fiber sheets were heated to a temperature of about 160 degrees F. Since the writer's experience with this blanking problem, he has recommended that the same type of dies be employed by another concern having a similar fiber blanking problem, and this company obtained equally good results.

* * *

At the annual meeting of the American Engineering Standards Committee, Charles E. Skinner, a representative on the committee of the American Institute of Electrical Engineers, was elected chairman for the year 1925, and Charles Rufus Harte, a representative of the American Electric Railway Association, was elected vice-chairman.



TRUING GRINDING WHEELS WITH DIAMONDS

As the diamonds employed in truing up or dressing grinding wheels are expensive, care should be taken to use them in the most efficient manner. The methods of presenting the diamond to the wheel illustrated in Figs. 1, 2, and 3 are not recommended by the writer. That shown in Fig. 2, although used on a few very fine grinding machines with good results, does not permit the diamond to render the best service of which it is capable.

The method that the writer has found to give the best results is illustrated in Fig. 4. With this type of mounting it is impossible for the diamond to dig into the work for the reason that the point at which the holder would fulcrum if the pressure against the wheel should become too great, lies above the center of the wheel. The downward angle at which the diamond is held causes it to be worn to a sharp point. Thus, if the operator turns the diamond slightly in its holder, a new or sharp point will be presented to the wheel. If a diamond is allowed to wear down in such a way that it becomes round or flat at the end, it will have a tendency to chatter. In the mounting shown in Fig. 1, the diamond is presented to the wheel at an angle, but the holder lies in the same horizontal plane as the grinding wheel spindle, and this has a tendency to cause chatter. If the operator should accidentally feed in too much, and the wheel is being fed toward the diamond longitudinally, we would have a condition that would be likely to result in a cracked diamond.

It is well to keep in mind the fact that although the diamond is the hardest substance known, it is very brittle. It is, therefore, likely to be fractured if subjected to sudden intense heat or if quenched in cold water when hot. It has always been the writer's practice to use the diamond without water. If water is not used to keep the diamond cool, the cuts must be light enough to prevent the generation of too much heat. When water is used, it must be supplied in sufficient quantities to keep the diamond entirely cool. However, if only enough stock is removed from the grinding wheel to keep it in good cutting condition, the heat generated by the truing operations will not be sufficient to cause the diamond to be fractured, provided the truing operations are properly performed.

Perhaps the two greatest sources of economy in using the diamond are the practice of turning it slightly in its holder after each dressing operation, and having it remounted before it is worn entirely down to the setting. It is poor economy to allow the diamond to be mounted by anyone but an expert. It should never be set in place by peening, but should be secured in the holder by casting a fairly soft metal around it. This metal should have a low melting point. The diamond should be mounted deep in the setting so that the point exposed is only large enough to give the proper amount of wear before remounting is necessary. If a considerable amount of the diamond projects from the

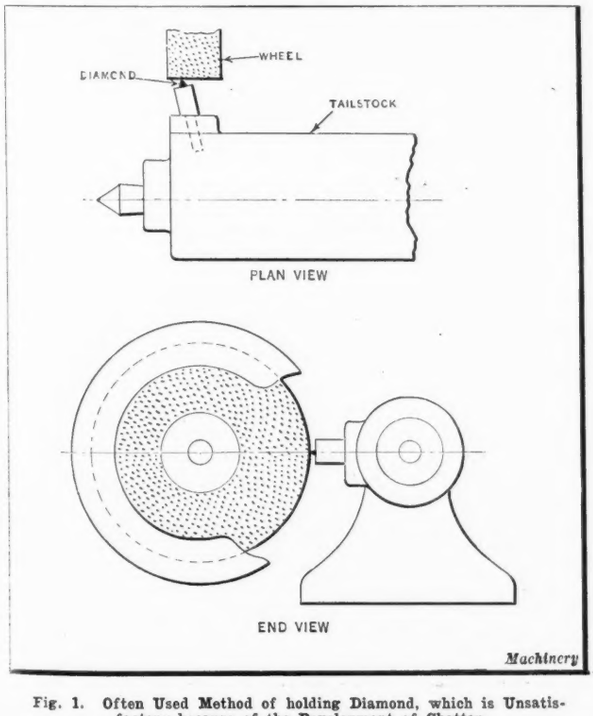


Fig. 1. Often Used Method of holding Diamond, which is Unsatisfactory because of the Development of Chatter

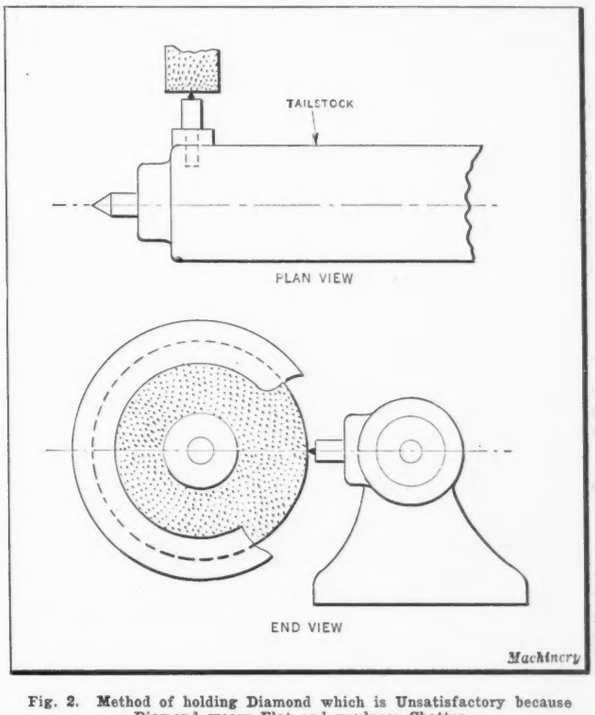


Fig. 2. Method of holding Diamond which is Unsatisfactory because Diamond wears Flat and produces Chatter

SIZES OF DIAMONDS FOR TRUING GRINDING WHEELS

Face Width of Wheel, Inches	Diameter of Wheel, Inches	Grade of Wheel	Weight of Diamond, Carats
⅜	Up to 3½	Medium-Hard	¾
½ to 1	3½ to 8	Medium	1½
1 to 1½	8 to 14	Soft to Medium	2
1½ to 2¼	12 to 18	Medium	3½
2½ to 4	18 to 24	Soft-Hard	5

Machinery

metal in which it is embedded, there is danger of its becoming broken or knocked out of its setting and lost. As a rule, about 75 per cent of the diamond should be embedded in the metal.

It is important that the truing diamond be large enough for the particular grade and size of wheel on which it is to be used. The accompanying table gives the sizes of diamonds that the writer has found best suited for truing some of the most commonly used wheels.

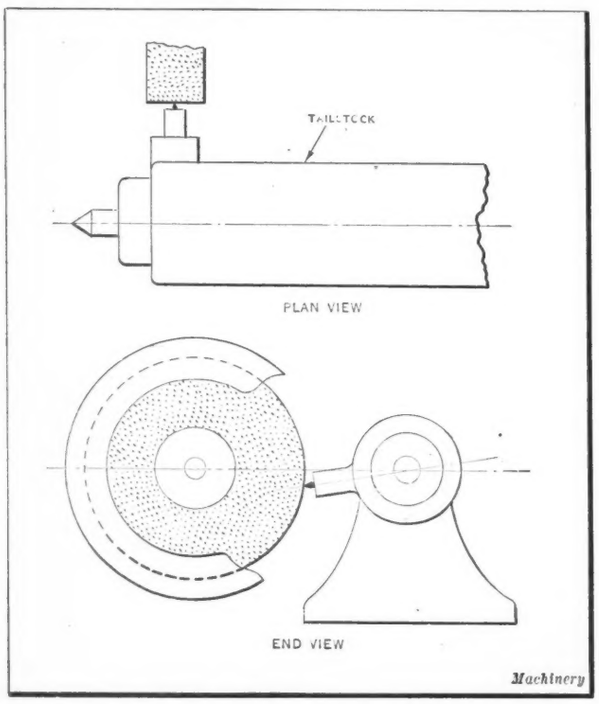


Fig. 3. Method of holding Diamond for Straight Dressing, which has proved to be Satisfactory

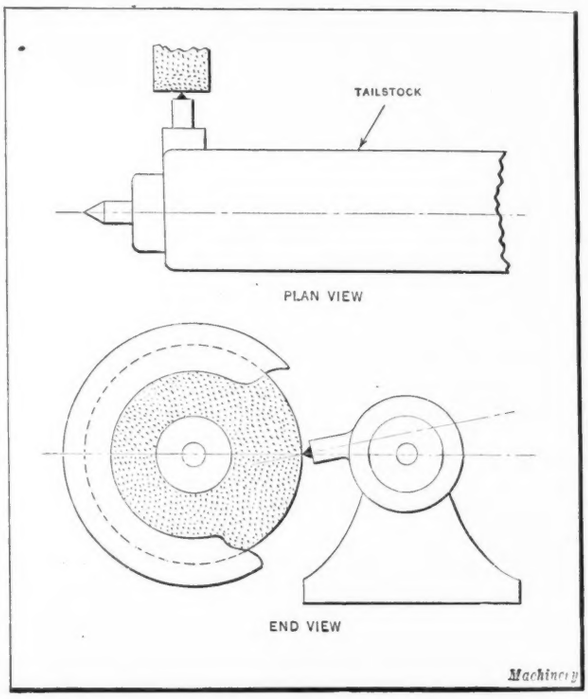


Fig. 4. Preferable Method of holding Diamond, which prevents Chatter and allows Diamond to wear to a Point

For grinding wheels having a face width greater than 4 inches and a diameter of 24 inches, a 6 or 7 carat diamond should be used. The greater surface speed of the larger wheels necessitates the use of heavier diamonds. Care should always be taken to see that the metal setting is not ground away from the diamond. It is cheaper to have the diamond remounted many times than to lose it through a faulty mounting.

Wheeling, W. Va. ARTHUR MUMPER

USING SUB-TABLES TO FACILITATE HANDLING BOX JIGS

On progressive gang drilling operations it is often necessary to tumble or turn a box jig over several times in order to complete the drilling, reaming, and tapping operations on the part held in the jig. This is easily accomplished if the jig is a small one, but when it is heavy and cumbersome, it is not such an easy matter. The strength of the machine operator will be taxed severely if he is required to tumble a 100- or 200-pound jig over every few minutes during the day. The pounding caused by the repeated tumbling of the jig also damages the finished surfaces of the table and the jig. In order to eliminate these difficulties, a manufacturer of automobile transmissions resorted to the use of sub-tables like those shown in Figs. 1 and 2, for handling box jigs used in drilling transmission case castings.

In Fig. 1 is shown a simple sub-base used for rolling a box jig a quarter of a turn at a time. The jig *A* is shown in the first position located on the sub-table *B* by stop *C* and the back-bar *D*. As soon as the first operation is completed, the operator pulls the jig toward him until it clears stop *C*, and then slides it to the left. The incline *E* should be about 55 per cent of the length of side *F* of the jig so that the jig will tip downward until its edge rests on the clearance slot *G*. Little effort is required to push it over the opposite incline so that it rests on the flat surface *H* and against the stops at the end of the sub-table. There is no heavy jar at any point in the turnover or tumbling operation. The sub-table is a casting that can be made in sections to suit any number of gang drills. The stops and back-bars should have relief grooves at the corners so that chips will not interfere with the proper locating of the jigs.

Sometimes it is necessary to turn a jig a half turn. To accomplish this, two turnovers or sub-tables like the one shown in Fig. 1 would be required; but in Fig. 2 is shown a single sub-table of simple design which enables the box jig to be rolled over a half-turn with but little effort on the part of the operator. Square axis blocks *J* are cast or fast-

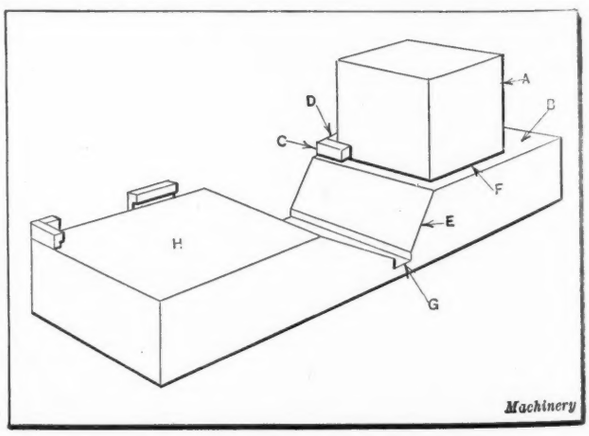


Fig. 1. Sub-table used in rolling Jig over One-fourth Turn

ended to the sides of the jig as shown. These blocks need not be over 3 inches square for the transmission drill jigs. They are located at an angle of 45 degrees with the base of the jig. The sub-table is provided with V-blocks *L* having an incline on either side of the vee. This illustration will make clear the manner in which the jig is turned over 180 degrees. Clearance is allowed at *K* for the corner of the jig as it revolves. Sub-tables like the ones shown in Figs. 1 and 2 can often be used in combination advantageously on the same line-up where a series of both quarter and half turns are required. The saving in time and wear on the jigs and table will quickly offset the cost of the sub-tables.

Indianapolis, Ind. WILLIAM F. SANDMANN

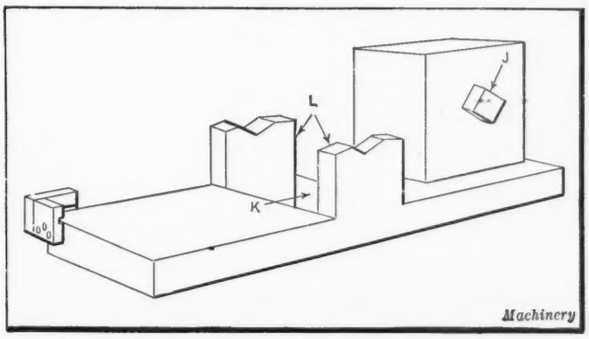


Fig. 2. Sub-table for Use in turning Jig One-half Turn

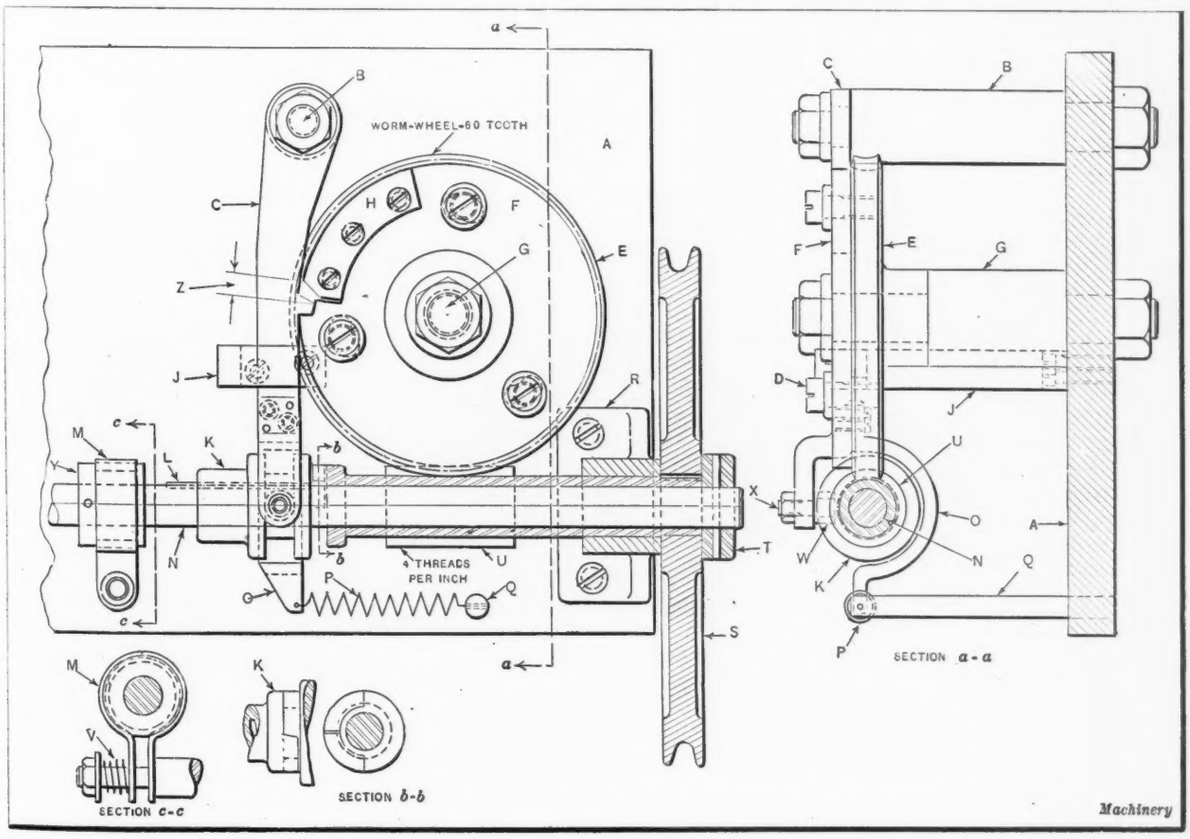
INTERMITTENT MOTION MECHANISM

The writer was recently confronted with the problem of providing an intermittent motion mechanism of rather an unusual type. The mechanism was required to drive a shaft at the rate of one revolution per second and have provision for adjusting the length of the regular periods at which the shaft remained stationary. The first job for which the mechanism was employed required the shaft to make one revolution in one second and remain stationary for fifty-nine seconds. The second job required the shaft to make three revolutions in three seconds and then remain stationary for fifty-seven seconds, while the third job required the shaft to make five revolutions in five seconds and remain stationary for fifty-five seconds.

The mechanism is shown in the illustration set up for the first job. Upon the machine base *A* is mounted the bearing stand *R* which is bored out to a running fit for the small end of the worm *U*. Shaft *N*, in turn, is made a running fit inside the worm *U* and transmits the intermittent motion to the machine proper, which is not shown in the illustration. The clutch member *K* slides on shaft *N* and is prevented from turning by a key *L*. On the face of the large end of worm *U* is a clutch tooth which engages the tooth on member *K*. The worm meshes with the worm-gear *E*, imparting a continual and uniform motion to the cam-plate *F*. The cam-plate pushes the lever *C* outward and thus disengages the clutch at the required intervals. The spring *P* provides for the return of lever *C* and the engagement of clutch *K* at the end of the period in which the shaft *N* is required to remain stationary. The brake-drum *Y* is keyed to shaft *N*, and is equipped with a steel brake-band *M* having a leather-lined contact surface. The pressure of the brake-band on the drum is maintained by a spring *V*.

When the mechanism is in operation, the grooved pulley *S* is driven by a belt from the lineshaft at a speed of 60 revolutions per minute. This pulley rotates the worm *U*, causing the worm-gear *E* and the cam-plate *F* to make one revolution per minute. Now as the worm has a single thread, it is obvious that a point on the circumference of the cam-plate will revolve a distance *Z*, which is approximately equivalent to the lead of the thread, or about ¼ inch.

After the cam-plate has been properly adjusted, it will not require changing except to compensate for wear. At the instant the cam-plate has reached the end of the travel *Z*, the corresponding movement of lever *C* disengages the clutch *K*, so that the rotation of shaft *N* is stopped exactly at the end of one revolution. The friction brake consisting of drum *Y* and band *M* prevents the momentum of the clutch and shaft from causing a further movement of the shaft.



Mechanism for producing Intermittent Motion

In order to obtain the necessary dwells required for the second and third jobs, the distance *Z* must be increased. This necessitates the use of interchangeable cam-plates *F*. For the second job, the dimension *Z* is three times as great as for the first job, and for the third job five times as great. Any other desired length of dwell may be obtained by providing a suitable cam-plate.

Bridgeport, Conn. JOSEPH E. FENNO

LATHE FIXTURE FOR ELLIPTICAL TURNING AND BORING

The fixture shown diagrammatically in Fig. 1 was designed primarily for use in the production of punches and dies for punching elliptical hand-holes in ⅜-inch boiler plate. In Fig. 2 the fixture is shown with a die clamped on the faceplate, in position for boring the elliptical hole. The arrangement for turning the elliptical-shaped punch used with this die is shown in Fig. 3.

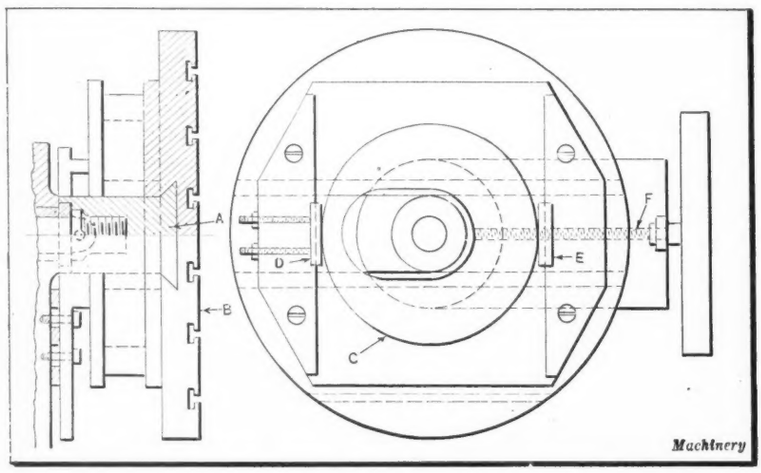


Fig. 1. Diagram showing Essential Members of Elliptical Turning and Boring Fixture

The fixture is very simple in design, consisting essentially of a dovetail slide *A*, Fig. 1, which is screwed on the lathe spindle in place of the usual faceplate or chuck. On this dovetail slide is fitted a sliding chuck or faceplate *B*, which is kept in position by means of a controller or ring *C*, located between and in contact with two hardened steel blocks *D* and *E* secured to the back of the faceplate. Ring *C* is mounted on a slide secured to the headstock of the lathe, and remains stationary when the device is in operation; however, it can be adjusted so that its center coincides with that of the lathe spindle, or moved off center any required amount within its range.

It will be noted that the T-slots in faceplate *B* are parallel with the dovetail slide. This facilitates the setting up of a square or rectangular block in such a position that the sides or ends of the block will be parallel or at right angles to the slide *A* in accordance with the required position of the elliptical hole. In adjusting the fixture to turn an elliptical-shaped punch or to bore an elliptical hole, the controller ring *C* is set off center by means of the adjusting screw *F* a distance equal to one-half the difference between the major and minor axes. For instance, if the required ellipse has a major axis of 3 inches and a minor axis of 2 inches, the amount the ring would be offset would be ½ inch. An important point to remember is that the point of the tool must be located at the same height as the center of the spindle; otherwise the work will be irregular in shape.

In turning a punch, the stock is usually rough-turned to a cylindrical shape having a diameter about ⅛ inch larger than the major axis. Controller *C* is then adjusted so that faceplate *B*, following the only path possible, moves back and forth on the dovetail slide, causing the work to be turned to an elliptical shape. When controller *C* is adjusted so that its center coincides with that of the lathe spindle, the fixture will turn the work round. The further the controller is adjusted off center, the greater will be the difference between the lengths of the major and minor axes of a turned punch or a hole bored in a die. When the punch has been turned almost to the desired size, the compound rest is adjusted to turn the taper required for clearance back of the cutting edge.

In boring out the die, the hole is first bored out round with controller *C* located on center, about ⅛ inch being allowed for finish-boring the elliptical hole. If there is considerable difference in the lengths of the major and minor axes, it is a good plan to remove the greater part of the metal by drilling small holes close to the scribed profile of the die opening.

THOMAS C. SMILLIE

Toronto, Ontario, Canada

* * *

GERMAN AUTOMOBILE INDUSTRY

In an article appearing in *Transatlantic Trade*, the journal of the American Chamber of Commerce in Berlin, a comparison is made between the American and German automobile industries, in which it is pointed out that in Europe, and more particularly in Germany, the evolution of the automobile industry has been along entirely different lines from the development in America. It is stated that 78 per cent of all the cars made in the United States sell at prices below $1000, and that only four out of one thousand cars built sell for more than $4000 a car. As a result, there is one automobile in the United States for every eight inhabitants.

In Germany, again, there is only one car for every 400 inhabitants. No attempt has been made to popularize the automobile on the European continent. Instead of attempting to meet the growing demand at home and to acquire a share of the world's markets by meeting the American quantity methods of manufacture with effective means, the German manufacturer has largely confined himself to reducing the size of his car below the normal, and has developed cycle cars, miniature automobiles, and every variety of small vehicles.

Obviously, the idea of the builders was to reduce the fuel consumption by employing smaller motors and to cut down costs by reducing the weight of the car to the lowest possible limit. This tendency has resulted in the development of a surprising variety of small cars of excellent performance as far as fuel economy, tire wear, and speed are concerned; but their appearance is such that they can hardly expect to compete with the low-priced American cars of standard size and equipment.

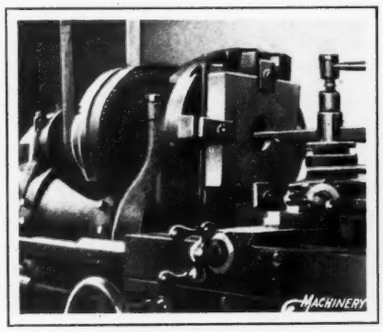


Fig. 2. Boring Elliptical Hole in Die

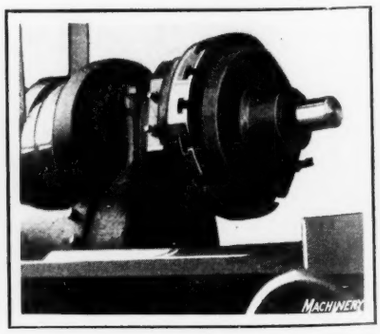


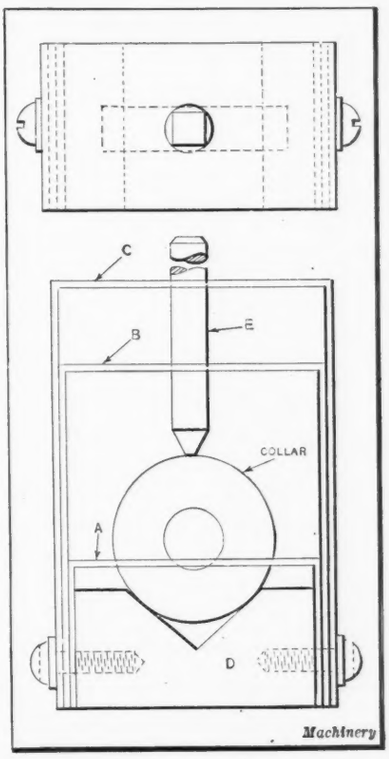
Fig. 3. Turning Elliptical Shaped Punch

Shop and Drafting-room Kinks

FIXTURE FOR STAMPING

A simple fixture that enables an unskilled workman or boy to stamp a neat row of figures on the periphery of a collar, is shown in the accompanying illustration. The fixture is made by bending three strips of sheet metal to the shapes indicated at *A*, *B*, and *C*, and securing these strips to a V-block *D*. The collar is placed in the V-block through a slot cut in the strip *A*. This slot locates the work in the correct position under the stamping punch *E*. The square shank of the stamp is a sliding fit in a square hole in strip *B*, which serves to keep the punch lined up with the center of the work.

HARRY MOORE
Rosemount, Montreal, Canada



Fixture for Use in stamping Figures on Collars

REMOVING THREADED CUTTER FROM ARBOR

After having tried all the old schemes for facilitating the removal of a threaded cutter from the arbor of a milling machine, the writer finally applied some Albany grease to the face of the cutter that made contact with the shoulder of the arbor. This proved much more effective than any of the old methods, such as using paper and copper washers.

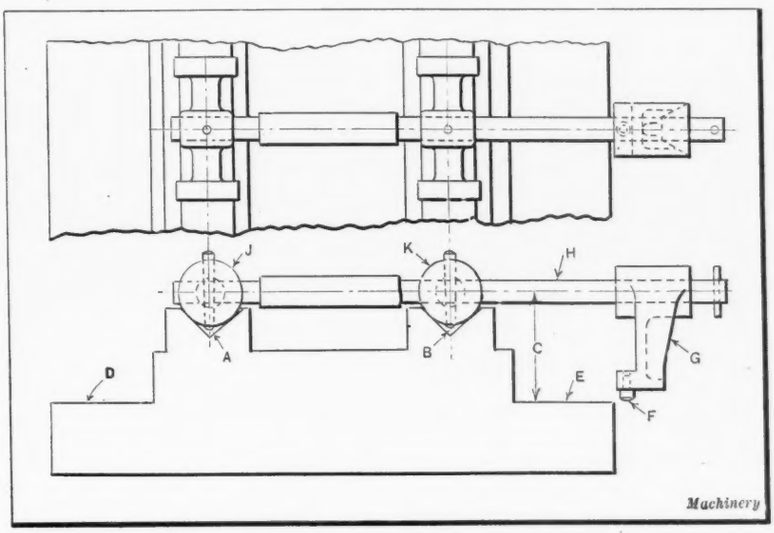
Portland, Me. H. K. GRIGGS

GAGE FOR V-GROOVE PLANING OPERATIONS

The gage shown in the accompanying illustration is used in planing the V-grooves at *A* and *B* in the tongues of a grinding machine table. When the grooves are finished, the height *C* of the center of the gage from the previously finished straightedge surfaces *D* and *E* must be exact. This is determined by the contact of the button *F* with surface *E* when bracket *G* is slid along extension rod *H* of the gage.

The gage is of simple design, consisting of only four parts, the two spools *J* and *K*, bracket *G* and extension rod *H*. The spools are made of tool steel and are hardened and ground. The bracket *G* is an iron casting which is a close sliding fit on the extension rod *H*. The hardened button *F* is made from drill rod, and can be easily replaced when worn at the contact end.

F. W. MING
Brooklyn, N. Y.



Gage for testing Height of V-grooves above Finished Surface

PRECAUTIONS IN USE OF CHISEL

Many workmen have lost the sight of an eye by being struck with a bit of steel broken from the head of a cold chisel, set punch, or other percussive tool. When goggles with safety glasses are worn, the danger to the workmen actually engaged in chisel work is reduced to a minimum; but nearby workers are still in danger. If the battered, ragged heads of chisels are ground off regularly, the chance of steel flying off and causing accidents will be comparatively slight, but precautions of this kind are difficult to enforce. The unsightly appearance and danger of ragged heads can be eliminated by proper heat-treatment of all chisels and similar tools. Tool-dressers should be impressed with the importance of hardening and tempering the heads of such tools as carefully as the cutting parts. F. C. D.

PROTECTION AGAINST FLYING BABBITT

Having seen many workmen seriously burned about the face and eyes by flying babbitt metal, the writer set out to devise a shield that would prevent such injuries. The shield finally evolved consists of a piece of plate glass, ⅛ inch thick and 6 inches square, which is mounted on a ½-inch steel rod. This rod, in turn, is secured to a vertical rod held in a cast-iron base, 6 by 9 inches by ½ inch thick. The rod attached to the glass plate was flattened out and formed to a T-shape, and the flattened part secured to the glass by three ¼-inch screws. The nut and clamp which secures the rod carrying the shield to the rod in the base permits the shield to be adjusted to any height and angle. The glass can thus be adjusted over the work in such a position that it will allow the workman to see just what he is doing, and at the same time protect him from any hot metal which may fly in his direction as a result of coming into contact with moisture.

CHARLES KUGLER
Philadelphia, Pa.

* * *

The taxes placed upon users of motor vehicles in 1923, federal, state and municipal, amounted to $471,548,000, according to figures compiled by the United States Bureau of Public Roads and the National Automobile Chamber of Commerce.

Questions and Answers

STRAIGHTENING PAPER CUTTING KNIVES

D. M. — I would appreciate information as to how to straighten paper cutting knives after heat-treatment. These knives are made from machine steel 1⅝ by 2 by 36 inches. To this is welded a tool-steel edge of Swedish steel, ¼ by ⅝ inch. In the heat-treatment of these knives, they bend out of shape, being concave on the flat surface and convex on the tool-steel edge. After straightening, the tool-steel edge is ground to a knife edge. If any reader of MACHINERY has had actual experience with work of this kind, will he kindly indicate how he straightened these knives successfully?

SHRINKAGE STRAINS IN CAST-IRON WHEEL

E. A. R.—We have experienced some difficulty in obtaining castings for a large six-spoked wheel that would be free from shrinkage cracks in the spokes. Can the pattern be modified in any way to eliminate this trouble?

ANSWERED BY JACOB H. SMIT, NEWARK, N. J.

As shrinkage strains are set up within the casting due to certain parts cooling off faster than other sections, especially in large wheels with heavy rims and hubs and light spokes, it is advisable to try to avoid unequal cooling by means of generous fillets in the corners and by fastening on each side of the spokes of the pattern, a piece of wood that is thin where it unites with the spokes and heavier a little away from it. The size of the auxiliary pieces depends on the size of the wheel spokes. By this means the heat of the auxiliary pieces will retard the cooling of the spokes, thereby avoiding unequal cooling. Either the pattern can be changed, or holes can be dug alongside the spoke cavity in the mold. After the casting has cooled off, the auxiliary pieces can be drilled or knocked off.

RESHARPENING FILES

K. B.—Can any reader of MACHINERY tell me how to resharpen files with acid solution?

ANSWERED BY JAMES P. BALDWIN, NEW BRITAIN, CONN.

In answer to K. B.'s question in January MACHINERY, relating to a process for renewing used files, the writer would recommend the following method:

Wash the files thoroughly in a strong solution of lye and water. When washed, clean them with a wire brush; then sort them according to the coarseness of the teeth and the amount of wear.

Make a wooden box large enough to hold the solution required for the renewing process and the files to be renewed. Line the box and all seams with rosin. Then make a solution from a mixture of one part of 38 per cent nitric acid, one part of 66 per cent sulphuric acid, and 18 parts of water. Before putting the solution in the box, lay the files in the box. Put pieces of wood under the ends of the files, so that the solution can play around them. After this is done, put the solution into the box.

The length of time required for renewing files is as follows: Fine files, from 8 to 10 minutes; medium files, from 10 to 15 minutes; coarse files, from 15 to 20 minutes. Those very much worn will require the longer time. Files can be renewed four or five times before their usefulness is past. The process described is simple, and only requires a little practice and judgment on the part of the operator.

Due precautions must be taken in handling the nitric and sulphuric acids, and the inexperienced operator should obtain from some responsible source, as for example, his local druggist, complete information in regard to the effects that these acids have upon the hands and clothing, and the methods that should be used in mixing them, in order that he may avoid danger and discomfort.

ANSWERED BY EDMUND C. PERSANS, BROOKLYN, N. Y.

A file to be sharpened or recut should be held in an acid bath consisting of three parts of sulphuric acid, one part of nitric acid, and seven parts of water. The time of immersion must be determined by experiment. After immersion, the file should be washed in clear water or in a milk-of-lime bath to clean it of the acid bath. Then the file should be brushed with a mixture of olive oil and turpentine, and dried with pulverized coke.

If files are to be cleaned only, this can be done by holding them for a minute or so in a steam current of about 40 to 45 pounds pressure. Another effective method for cleaning grease-clogged files is to boil them for a few minutes in a strong solution of soda and water. This cuts the grease and frees the dirt and filings so that a little scrubbing with a brush and hot water will clean them fully before rinsing. After rinsing, they are dried by heating. If the files still contain particles, these can be removed by rubbing in the direction of the file teeth with a piece of brass or picking with the point of a scriber.

MACHINING A HOLE ALONG AN ARC

W. E. H.—Will some reader of MACHINERY who has had experience in producing pieces similar to the one shown in Fig. 1, describe the machining methods employed? The pieces are to be made from steel and are cyanide-hardened.

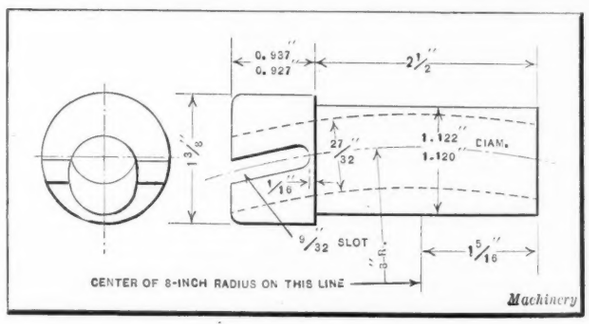


Fig. 1. Piece to be machined

ANSWERED BY CHARLES A. TRASK, INDIANAPOLIS, IND.

While the writer has had no experience in producing the part shown in Fig. 1, his method of approaching the problem would be as described in the following. First it is assumed that a tolerance of 0.010 inch is permissible where fractional dimensions are given and that from 500 to 5000 pieces are required. The first operation would be cutting off the stock, and the second, heating and then bending the cut-off piece in a press, using dies having the center of the bending groove machined to a radius of about 7⅞ inches. In the third operation, the part would be held in a suitable jig while drilling the 27/32-inch hole, starting from what later will be the large end of the piece.

In the fourth operation, the piece would be straightened in the press, using suitable dies, the curve of the half-round grooves being a fairly close fit on the work in order to lessen the danger of flattening the hollow stock. For the fifth operation, a round-faced milling cutter would be used to mill the 9/32-inch slot, which appears to be straight. The work may be held or positioned for this operation in a jig or vise by a bent pin, which is a good fit in the curved hole.

The sixth operation may be performed in various ways. If a 60-degree center, 1/16 inch deep, in the small end of the piece is not objectionable, the 27/32-inch hole may be beveled to receive the tailstock center in such a manner that the work will be properly supported while turning the small end to a diameter of 1.120 to 1.122 inches. If the center is objectionable, the pieces can be cut off from 1/16 to 3/32 inch longer than required for the finished part, and the centered portion cut off after the turning operation has been performed. This cutting-off operation may be performed in a lathe or on a drill press, using a 1⅛-inch end-mill with a sleeve pressed over its cutting end. The sleeve should project beyond the face of the mill far enough to support and align the work. A hardened steel center piece should be made to hold the large end of the work. This piece should have projections on each side to fit the 9/32-inch slot and should be 13/16 inch long. The projections should also have shoulders that will center the steel piece in the 27/32-inch hole.

By proceeding in the manner described, we have a straight lathe job. The tools may be arranged in a toolpost turret, the first operation being to face the large end and cut down the shoulder to a diameter of 1.220 inch. The tools may be set and both cuts taken simultaneously. Stops should be arranged to insure turning all the pieces to the same diameter without calipering each one. It might be well to make two of the hardened steel centers in order to permit the operator to fit a center in a new piece of work while the machine is at work on another piece.

ANSWERED BY ELMER C. COOLEY, EASTWOOD, N. Y.

The method of machining the piece shown in Fig. 1 which is here described is submitted in answer to the problem found on page 310 of December MACHINERY. In the first operation, the piece can be cut to length and centered or turned and cut off in an automatic screw machine. After turning and cutting off the piece *A*, Fig. 2, a 3/16-inch hole is drilled to a depth of 3/16 inch, as shown at *a*, view *B*. This hole provides a means of quickly locating the work by means of a stud held in the fixtures when rough-drilling and boring the piece in succeeding operations. The small locating hole is so positioned that it is completely cut away when milling the 9/32-inch slot; during the performance of this operation the 3/16-inch stud is required to be held on a swinging arm.

For the third operation, the work is drilled from both ends, as indicated at *C*, with a 23/32-inch drill. When performing these drilling operations the work should be held

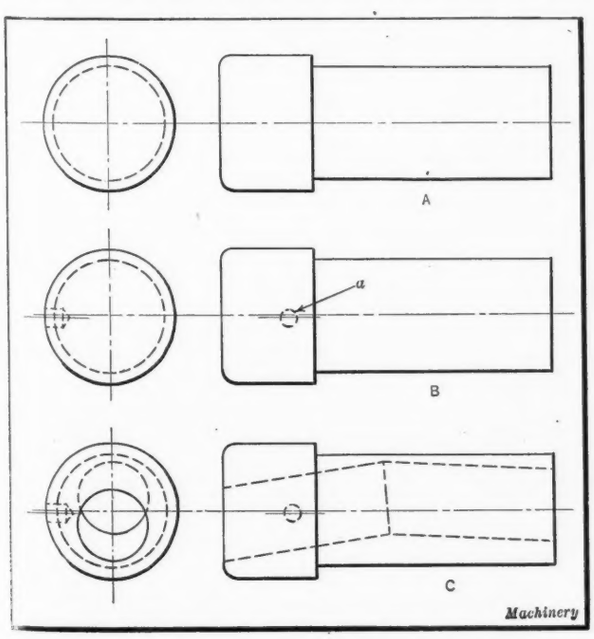


Fig. 2. Successive Operations in machining Special Stud

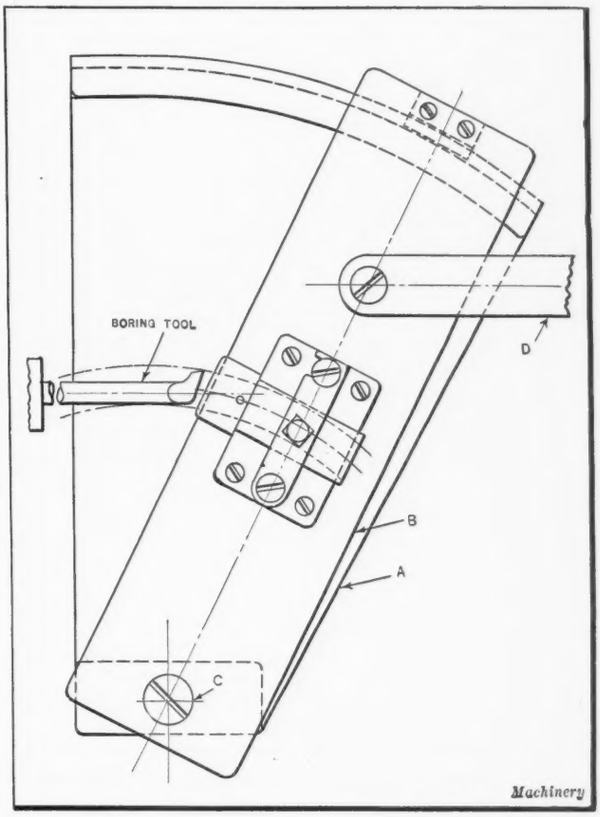


Fig. 3. Fixture used in boring Hole along an Arc

in a drill jig of the "turn-over" type. The fourth operation, which is that of boring out the 27/32-inch hole along the arc of a circle having a radius of 8 inches, is performed in a lathe provided with the fixture shown in Fig. 3. The cast-iron base *A* of this fixture is clamped securely to the lathe bed. The arm *B*, which is made from a piece of steel bar stock, swings on the stud *C*, which is so positioned that it gives the correct curve to the hole. Power feed is obtained through the movement of the lathe carriage which is connected to the arm *B* by a link *D*. It will probably be found best to take a rough and a finish cut when boring the 27/32-inch hole. The fifth and final operation consists simply of milling the 9/32-inch slot.

ANSWERED BY L. B. EWEN, MONTREAL, QUEBEC, CANADA

The following is a description of a method of machining the piece shown in Fig. 1 which the writer believes will be found satisfactory. The first operation should be performed on an automatic machine, and consists of turning and cutting off the piece, which should have the shape indicated at *A*, Fig. 4. A drilling machine is used in the second operation to drill two ¾-inch holes, one from each end of the piece, as shown at *B*, so that they will intersect or meet at the proper point to conform with the finished 27/32-inch hole shown at *C*. It is advisable to employ an indexing jig when drilling the ¾-inch holes.

For the third operation, a cutter like the one shown at *F*, mounted on a spindle of the type shown at *E*, is used to finish the 27/32-inch diameter hole indicated at *C*. This operation is best performed on a vertical milling machine in a specially designed fixture which will revolve about the center of the 8-inch radius. A simpler fixture can, of course, be employed in connection with a standard revolving circular machine table which would be mounted on an angle-plate. The shape of the arbor shown at *E* is, of course, determined by the radius of the inner edge of the 27/32-inch hole. The small cutter shown at *F* has a diameter of 27/32 inch, and is ½ inch wide. This cutter is held on the arbor by a large flat-head screw. A small plug driven into the face of the arbor which fits into a small semicircular keyway in the cutter prevents slipping.

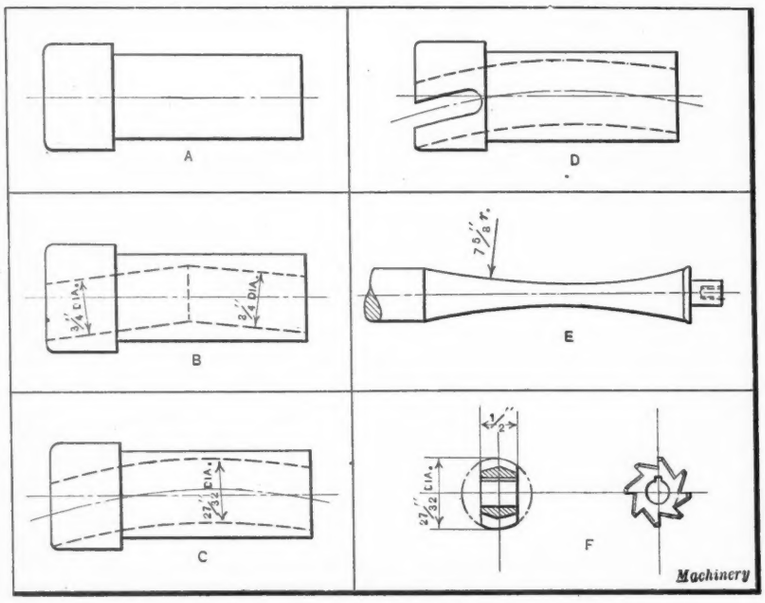


Fig. 4. Methods and Tools used in machining Piece shown in Fig. 1

While there are several methods by which the 9/32-inch slot can be machined, the writer would prefer to do this work on a Pratt & Whitney splining machine, using both headstocks and cutting the slots from both sides of the piece. A special holding fixture would be required for this job, but it would be of simple construction. Another method of producing the slot would be to use a vertical end-mill, clamping the piece to a standard revolving circular table and feeding the end-mill down at the completion of every stroke.

ANSWERED BY R. P. CHANDLER, WESTPORT, CONN.

In answer to the production problem given on page 310 of December MACHINERY, the writer submits the following solution. Assuming that the pieces are to be made from bar stock 1⅜ inches in diameter, the first operation would be to turn the 1.122-inch portion of the work, round the corner, and cut the piece off to length. For the second operation, the piece should be held at an angle of 3 degrees, as indicated in Fig. 5, and a 27/32-inch end-mill used to spot the upper end, as indicated by the dotted lines. The third operation would consist of spotting the large end of the work with a 27/32-inch end-mill to correspond with the circular hole. For this operation the work should be held at an angle of 10 degrees, as indicated.

The fourth operation would consist of drilling an 11/16-inch hole half way through the piece, which is held in the same position as for Operation 2. The fifth operation, which is that of drilling an 11/16-inch hole half way through the piece to meet the first hole, as indicated, is performed with the piece held in the same position as for the third operation. For the sixth operation, the piece is located on a circular milling attachment at an angle of 17 degrees and the 27/32-inch hole milled half way through the piece from the small end.

The seventh operation consists of finish-milling the remaining half of the 27/32-inch hole from the large end while the work is held at an angle of 20 degrees. For the eighth operation, the work is held at an angle of 14 degrees 30 minutes with the center line of the spindle, and the 9/32-inch slot milled in the large end of the piece, using a vertical milling attachment. In the ninth operation, the 9/32-inch slot is milled on the opposite side of the piece, the position of which is reversed as indicated.

If the number of pieces required is sufficient, quick-acting milling machine vises with special jaws should be provided. A ⅞-inch end-mill may be ground down to the required diameter for milling the 27/32-inch hole. In setting up the circular milling attachment for Operations 6 and 7, care should be taken to have the center line of the circular hole located on an 8-inch radius. The attachment should be revolved until the center line of the piece (but not the center line of the circular hole) is at an angle of 17 degrees for Operation 6 and at an angle of 20 degrees for Operation 7. A convex milling cutter 27/32 inch in diameter with a 3/16-inch radius, mounted on one end of an arbor having a 5/8-inch shank, can be used in finishing the 27/32-inch hole. It is necessary to set the work at the 17- and the 20-degree angles previously mentioned in order to permit the 5/8-inch shank of the milling arbor to clear the work when the cutter has been advanced half way through the piece.

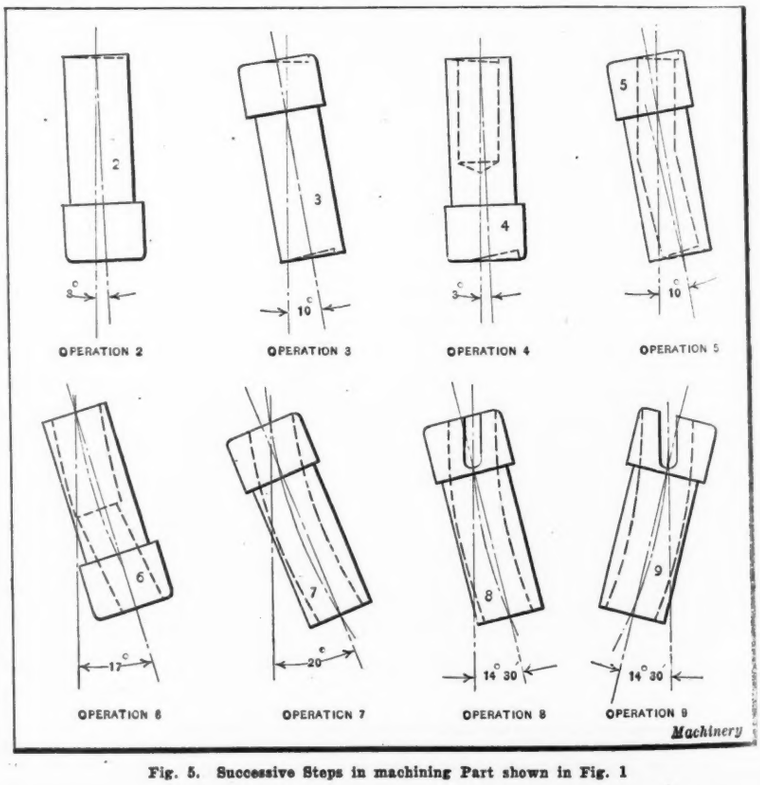


Fig. 5. Successive Steps in machining Part shown in Fig. 1

PRODUCING FLAT BRASS BLANKS

N. H.—We have found some difficulty in obtaining absolute flatness in half-hard, practically semicircular, brass plates measuring 3½ inches by 2 inches by 0.020 inch thick. The brass comes in long flat strips 3⅝ inches wide, out of which these blanks are stamped. Is there any practical method of embossing or pressing the surface to obtain absolute flatness? The plates as they come out of the press are wavy and distorted.

* * *

The exports of all classes of electrical equipment from the United States during 1924 are valued at approximately $85,000,000, exceeding the value of the exports in 1923 by about $12,000,000.

THE VALUE OF PHOTOGRAPHY TO THE MACHINE BUILDER

By DONALD A. HAMPSON

Photographs of complete machines have been found of great assistance in assembling duplicate machines, and the difficulty in making the manufacturer of a machine understand what parts are required for replacements or repairs can be eliminated by furnishing photographs of the parts desired. When sizes and other written data are not required, a photographic record will usually take the place of a regular drawing satisfactorily, and can generally be made at a fraction of the cost of a drawing.

The accompanying illustration is a reproduction of a photograph made by an amateur, such as might be obtained by any employe in a drawing-room, shop, or shipping department. The story of this photograph shows the possibilities, mechanical and monetary, of a photographic record. A dealer in machinery in the Hawaiian Islands ordered two machines from a plant located in northern New York. Packed in the standard export crates the machines traveled 300 miles to New York City and there were lowered into the hold of a steamer that in due time arrived at the port of Honolulu, Hawaii.

An observant employe of the dealer at Honolulu noticed that something in the crate had been broken, as it was about to be loaded on a motor truck at the pier, and he accordingly refused to accept the shipment even though the crate appeared to be in good condition. On opening the crate the bed casting of the machine was found to be broken in the middle, as shown in the illustration. This illustration, which is a reproduction of the photograph referred to, also shows that a side plate and a piece that fitted into the center slot were broken. It was obvious that the crate must have been given a very heavy blow, as the superstructure of the machine and the special construction of the crate adequately protected the part from any damage that could result from ordinary handling during transportation.

Photograph that served to identify Broken Part and prove that Damaged Crate had been repaired

The claims for settlement were passed back and forth between Hawaii and the shipping point in northern New York. The photographs of the crate and the machine which someone connected with the company at Honolulu had thoughtfully taken, played a leading part in securing a settlement for the damage to the machine while in the hands of the transportation company. The photograph showed where the break occurred and the condition of the packing. As the crate or packing directly over the broken part was designed to withstand a blow of 800 pounds with a safety factor of 5, and the machine was capable of withstanding a blow many times as great, it was evident that the loading of the ship's hold was carelessly done or that some accident had occurred while loading that permitted a heavy object to crash through the packing case. But more important than this, was the fact that the photograph showed that someone, not located, had skillfully patched the crate before it was lifted out of the ship's hold to the dock. The photograph of the crate showed the truth of this assumption very plainly to the factory in northern New York, although the Hawaiian dealer was unaware of this fact when the photograph was taken.

An inspection of the photograph showed that a piece of wood about 1½ inches wide without any grain, had been used in repairing the damaged crate, whereas the company that shipped the machine had used only hard pine having sappy streaks or grain such as may be seen on the end and face of the crate which were included in the photograph. On the presentation of such conclusive evidence, no trouble was experienced in obtaining a satisfactory settlement from the transportation company. The time saved by using the mails instead of shipping the parts back to the factory, the trifling cost of this method, and the certainty that both the manufacturer and the dealer, who were located so far apart, would make no mistake as to what parts were referred to in their correspondence, speaks volumes for the value of photographs in such instances.

Only a glance at the photograph was necessary to show the manufacturer just what parts would be required to repair the damaged machine. The manufacturer also knew from the nature of the break, as revealed by the photograph, that two steel parts that were not shown were necessarily badly bent and that it would be better to include new parts rather than have the dealer attempt to straighten them, as he had intended to do.

* * *

MACHINERY EXPORT MARKET IS FAVORABLE

According to statistics collected by the Industrial Machinery Division of the Bureau of Foreign and Domestic Commerce, of which division W. H. Rastall is chief, the American machinery manufacturer now participates in the world's markets to a greater extent than ever before. In pre-war days Germany was peculiarly successful in the world's machinery trade. For example, in 1913 she furnished 25 per cent of the machinery imported into Japan. Since the armistice Germany has at no time furnished as much as 10 per cent of the machinery imports to Japan. On the other hand, although the United States previous to the war never furnished over 20 per cent of the machinery imported into Japan, its share in 1919 was 64 per cent; in 1920, 63 per cent; in 1921, 48 per cent; in 1922, 50 per cent; and in 1923, 42 per cent. These figures are the more significant, as the total volume of the machinery imports into Japan have greatly expanded, as compared with the pre-war period, and in value are now from three to four times as great as they were in the most active pre-war year.

Although Great Britain furnished over 68 per cent of the machinery imported into Japan in 1910, and held a share of over 50 per cent in every year including 1915, British manufacturers have not been able to recover anything like this participation since the trade was interrupted by the war. In 1923, Great Britain supplied 37 per cent of the machinery imported into Japan.

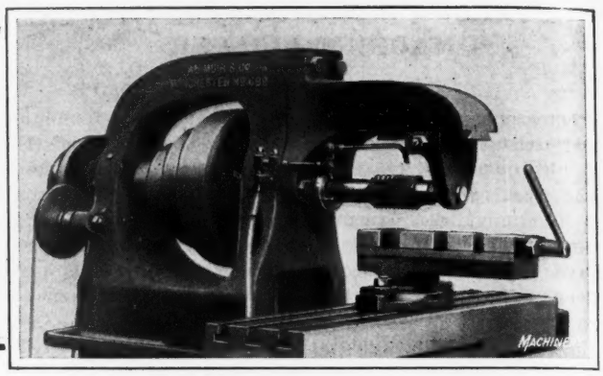
* * *

REGIONAL MEETING OF NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION

A regional meeting of the National Machine Tool Builders' Association was held at the Biltmore Hotel, Providence, R. I., January 20, representatives of machine tool builders in New England, New Jersey, and New York being present. The meeting discussed a number of the problems common to machine tool builders in general. The president of the association, O. B. Iles, president of the International Machine Tool Co., Indianapolis, Ind., presided, and Ernest F. DuBrul, general manager of the association, introduced the proceedings by a statement relating to the general industrial conditions and the prospects for machine tool sales in 1925. A luncheon was given for the visiting members of the association by the resident Providence members. Among the topics discussed were association advertising, cooperative research work, the second-hand machinery market problem, accounting problems, and the place for the general spring meeting of the association.

Milling Machine Over-arms

By FRED HORNER



THE plain and universal milling machine has been constantly improved to enable it to meet the ever-increasing demands of production. These improvements include stronger frames and columns, stronger spindles and driving gear, greater stiffness in the knees and tables, and increased efficiency as regards supplementary supports. A great many knees are provided with supports from the base, and some with stays that extend from the over-arm to the base and are tied to the knee; but the majority of designs have the simpler brace arrangement extending from the over-arm to the knee. The value of this support depends upon the strength of the over-arm. Unless the over-arm possesses ample stiffness, it is of little use to arrange for heavy braces, for the knee and the arbor will still be deflected.

Until a comparatively recent date, the type of over-arm generally used was the simple round bar passed through split lugs above the spindle bearings, and clamped by a screw in each lug. The practice of bolting or casting an arm or tie-bar from one spindle bearing to the other, and projecting out a round arm from this provided a stiff construction, as in early Brown & Sharpe practice. A leading English firm of machine tool makers, William Muir & Co., Ltd., of Manchester, can also point back to an example of very stiff construction, as shown in the heading illustration. This photograph was taken in 1886, but machines of similar type had been made prior to that date. The head is not only cast with a tie-bar of stiff section, but the box-section over-arm represents a departure from the usual round bar, its arbor support being split and clamped to a V-slide. This support is always in alignment, and cannot be displaced nor pushed out of line by heavy cutting. The present-day tendency is toward some such method of self-aligning and prevention of twisting.

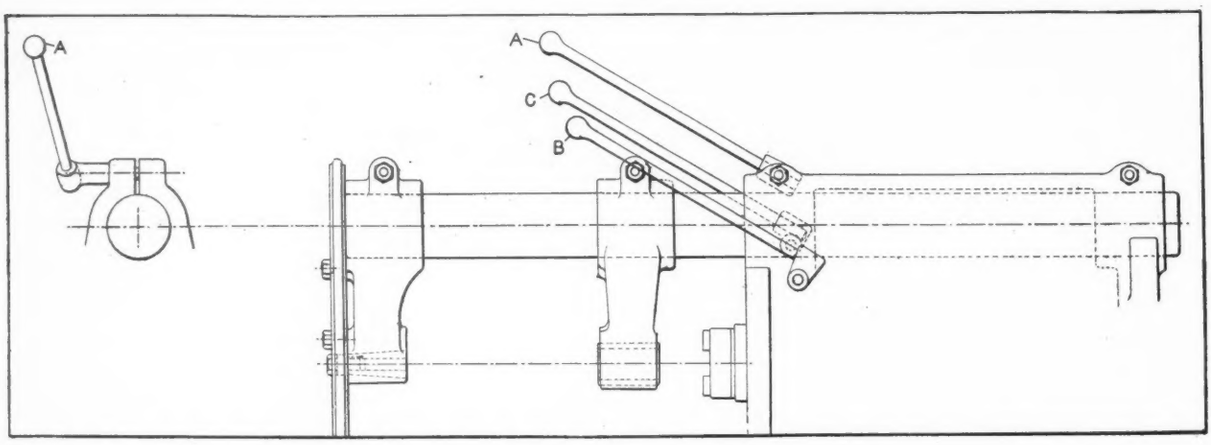


Fig. 1. An Over-arm with Long Lever Control of Front Clamping Bolt

Not much diversity exists in connection with the ordinary split lugs for slidable arms, but there are two arrangements that are worthy of note. The first is illustrated in Fig. 1; here it will be seen that a long lever *A* brings control of

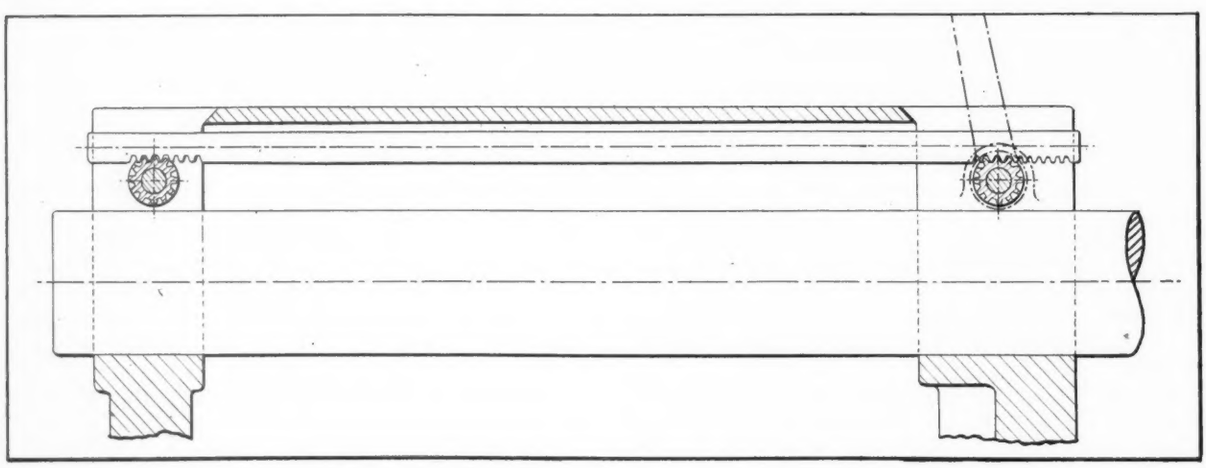


Fig. 2. Rack Bar for Simultaneous Operation of Two Clamping Bolts

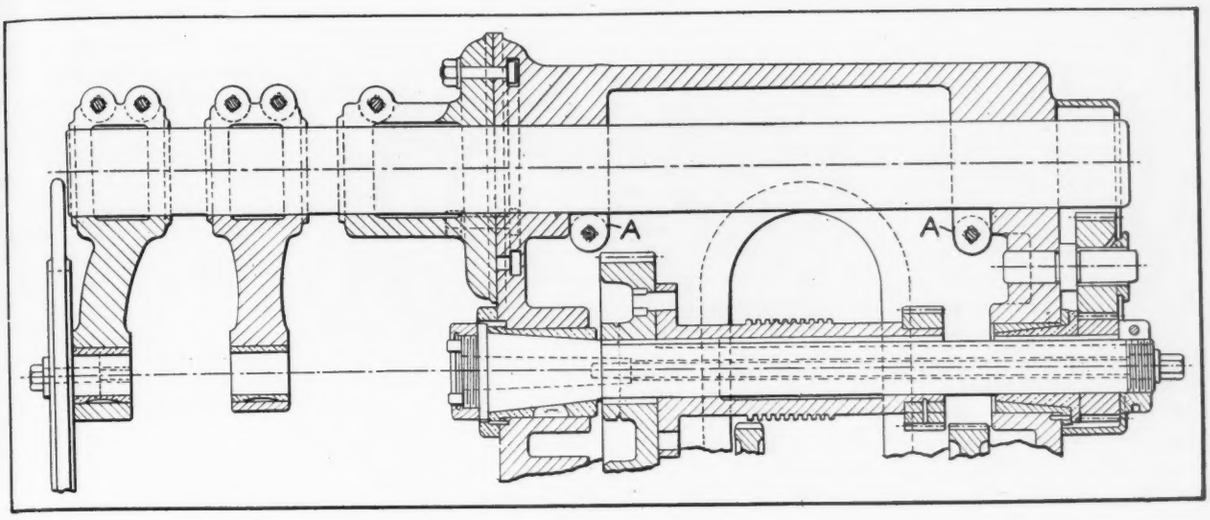


Fig. 3. Milling Machine Over-arm with Band Clamps and Flanged Support

the front tightening bolt within easy reach of the operator when he is standing in front of the machine. The rear bolt is only tightened when specially heavy cuts are being taken. The flanking levers *B* and *C*, of similar pattern, are for controlling the starting and stopping, and the quick power traverse, respectively. This arrangement is found on the machines of J. Parkinson & Son, Shipley (England).

Another arrangement is found in the Brown & Sharpe machines, where front control is afforded to both clamping bolts on the firm's smaller machines. Each nut is of the sleeve type, with teeth cut on the exterior. The clamping lever (see Fig. 2) turns the nut at the front and tightens the bolt, and, through the rack bar, a simultaneous tightening occurs at the rear. Fig. 4 shows the sectional appearance at this end, and shows how the bolt is prevented from turning by a pin, and can be adjusted endwise by the nut and binding screw.

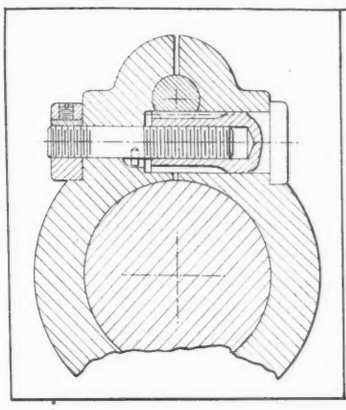


Fig. 4. End View of the Arm shown in Fig. 2

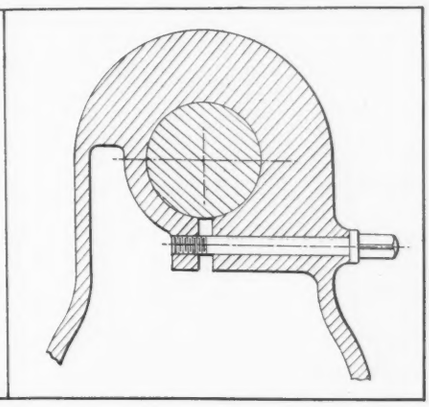


Fig. 5. Design of Clamping Lug on Arm shown in Fig. 3

A different method of splitting from that ordinarily used is found in the smaller sized machines made by the Rockford Milling Machine Co. The column casting is solid at the top but has a couple of bands *A*, Fig. 3, so as to leave continuous metal around the arm at the back and front. The enlarged cross-section, Fig. 5, indicates how the grip reaches over 180 degrees of the circumference. Increased rigidity is also afforded by a flanged support at the front end, bolted to the seat on the column, and split to grip the arm. Fig. 7 represents the universal all-geared machine with this arrangement.

A mode of clamping is also used that obviates the necessity of splitting the head casting, clamping bolts being used instead to press against the over-arm. Sometimes the bolts are placed below, sometimes above. In a line of high-power machines built by Smith & Coventry, Ltd., of Manchester (England) the latter plan is adopted, as shown in Fig. 6, so as to force the arm downward.

The problem of alignment has been solved in several ways; the object is to automatically bring the outboard and intermediate arbor supports into line with the spindle axis, a feature not guaranteed in any way with the ordinary round over-arm, which, moreover, is not immune from slipping. An obvious device is to have a spline cut along the arm, and use a locating key or keys. One simple mode of utilizing this principle may be observed in Fig. 8. The top part of the spindle slide contains the over-arm, and locating and clamping are alike effected by the keys and set-screws, the arbor supports being locked similarly.

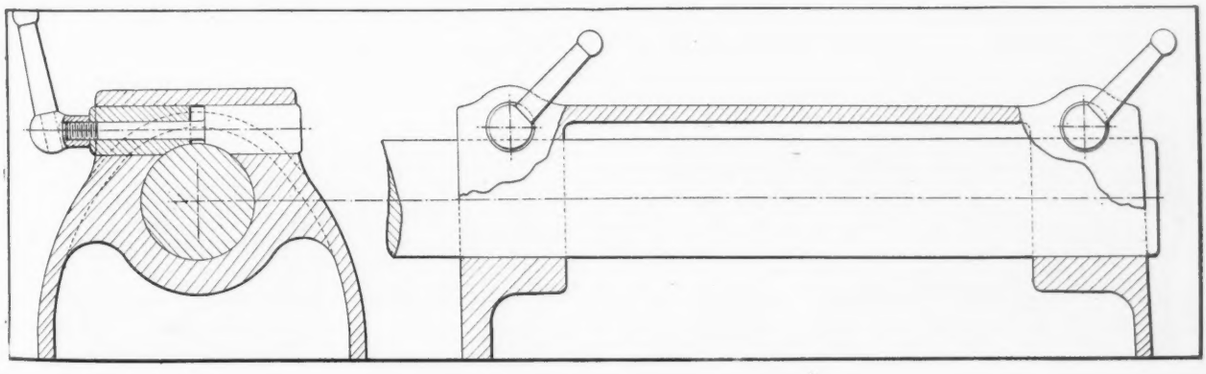


Fig. 6. Design of Over-arm clamped with Pad Bolts

In the foregoing example no splitting occurs, but in certain types the keyway principle is added to the split method. In the Hendey millers, a splined arm engages with a key anchored in a split bushing which is carried in the front housing of the column. This bushing has a positive stop which registers the location of the arm and the alignment of the pendant center with the center of the main spindle.

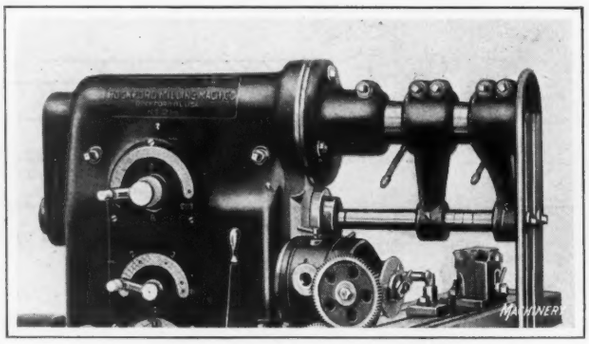


Fig. 7. Flanged Support for Over-arm

The R. K. Le Blond Machine Tool Co. has a system of spline location, the column head and each arbor support being fitted with aligning plugs of the style shown in Fig. 12. The actual support of the arm is derived from the split lugs in the column and the supports (see also Fig. 17) together with shouldered studs as seen in Fig. 12.

straight flank of the slot is lined up with the spindle center, and the arbor supports bored and reamed in place. It will be noted that the screws for setting in the plugs are made with two coarse-lead threads, of opposite hands. The smaller screw forces the plunger in, and the larger one feeds itself into the nut with the same movement, giving a quick action with a very small motion of the handle.

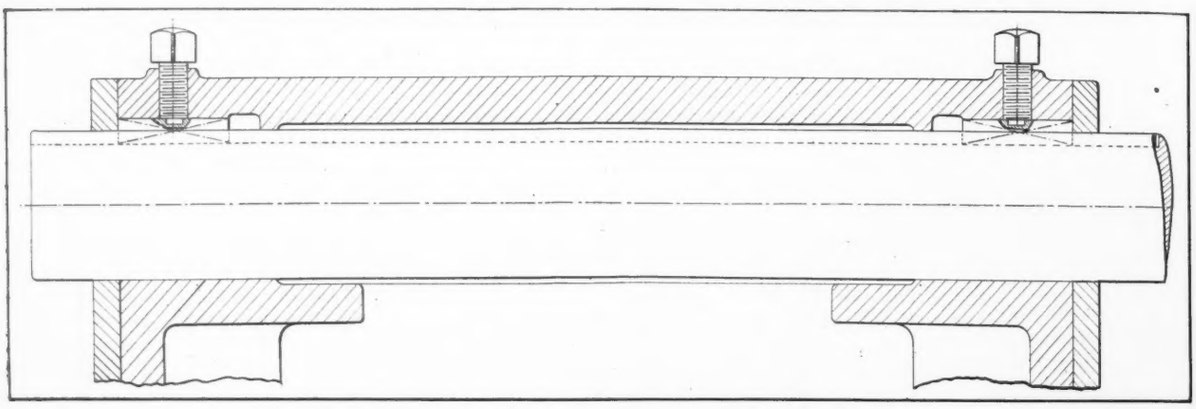


Fig. 8. A Simple Method of locating and clamping a Splined Arm

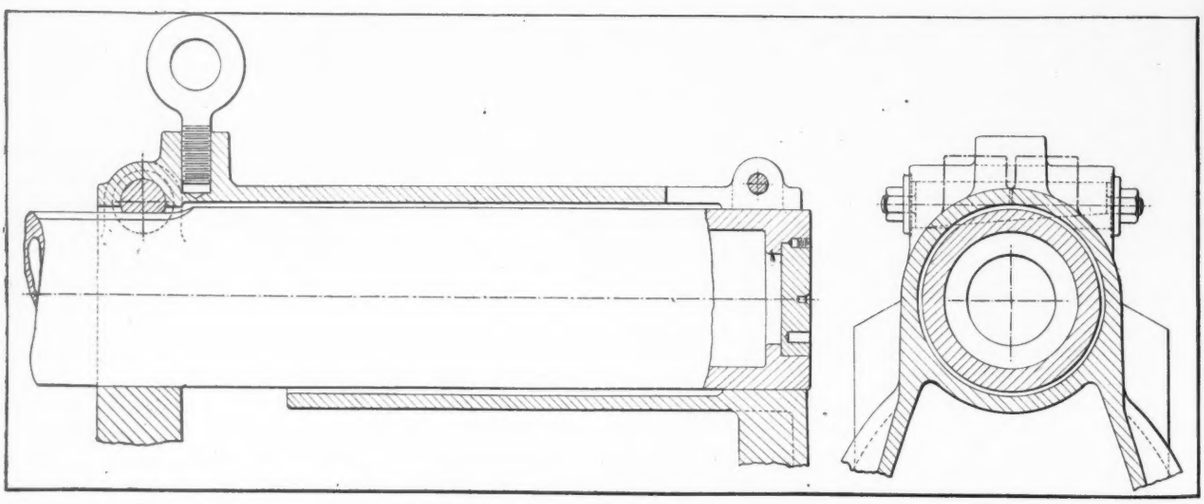


Fig. 9. Arm with Wedge-bolt Fastening

Fig. 12. The spline has a straight and a taper side, the taper drawing the over-arm down to a seat on the flat side of the plug. Accurate location is thus insured, because the

A composite arrangement is utilized on the Kempsmith machines, with a split rear lug to be adjusted to a nice fit, and wedge-bolt locating and clamping devices at the front

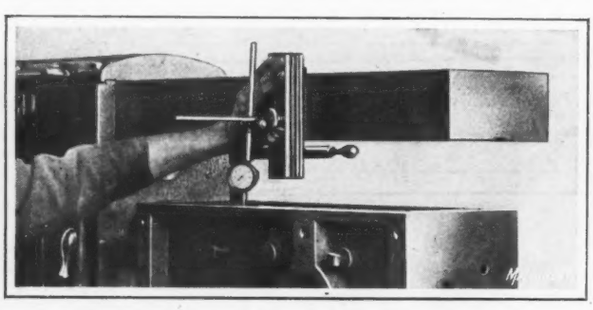


Fig. 10. Using a Test Indicator on the Scraped Surface of an Arm

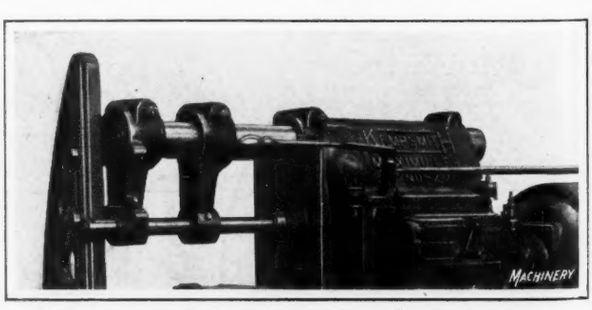


Fig. 11. Wedge-bolt System of clamping the Arm illustrated in Fig. 9

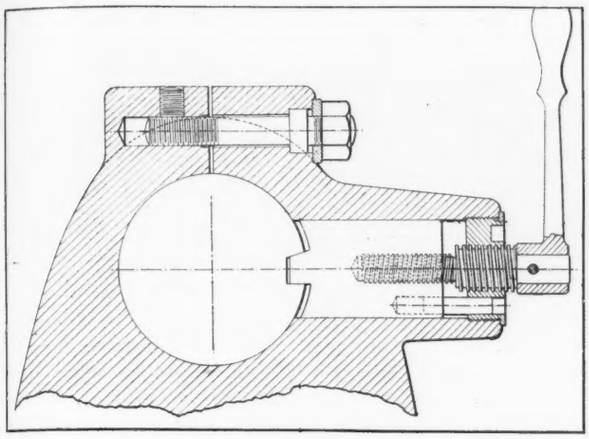


Fig. 12. Quick-acting Wedge-block and Binding Bolt Arrangement for Over-arm

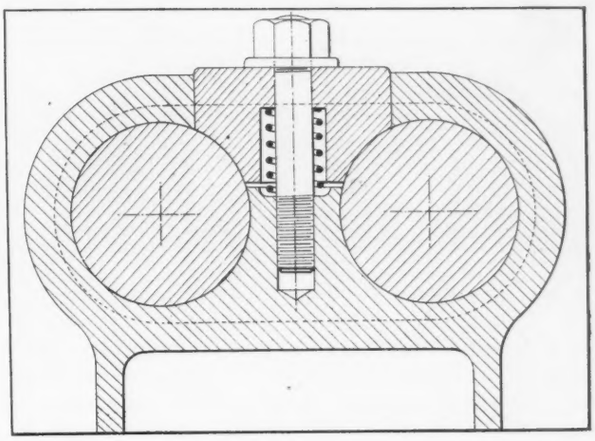


Fig. 13. Clamping Block for Over-arm with Spring for raising the Block

and for each pendant. A flat seat cut part of the way along the bar makes contact with the respective wedge-bolts, which automatically locate all the members; the sectional view, Fig. 9, explains the action in the column, and the remainder of the arrangement may be understood from an inspection of Fig. 11.

The use of two cylindrical arms provides both for greater rigidity and for positive alignment without the necessity for keys or flats. This method is found in the Kearney & Trecker millers. It demands a high degree of accuracy in boring the two over-arm holes parallel with the spindle holes and with each other. Even if only the outer arbor support is wanted to sustain the arbor, the other should be turned bottom side up and clamped, to insure maximum rigidity. The two illustrations, Figs. 14 and 15, give an idea of the arrangement. Split grips lock the arbor sup-

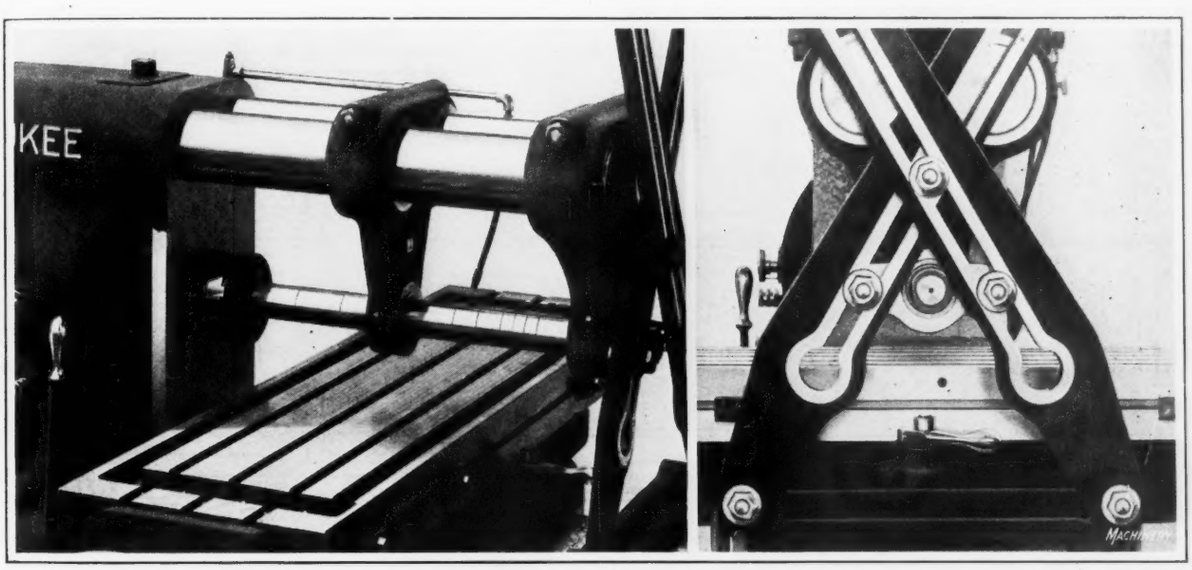


Fig. 14. Milling Machine with Double Over-arm

Fig. 15. Arrangement of Braces

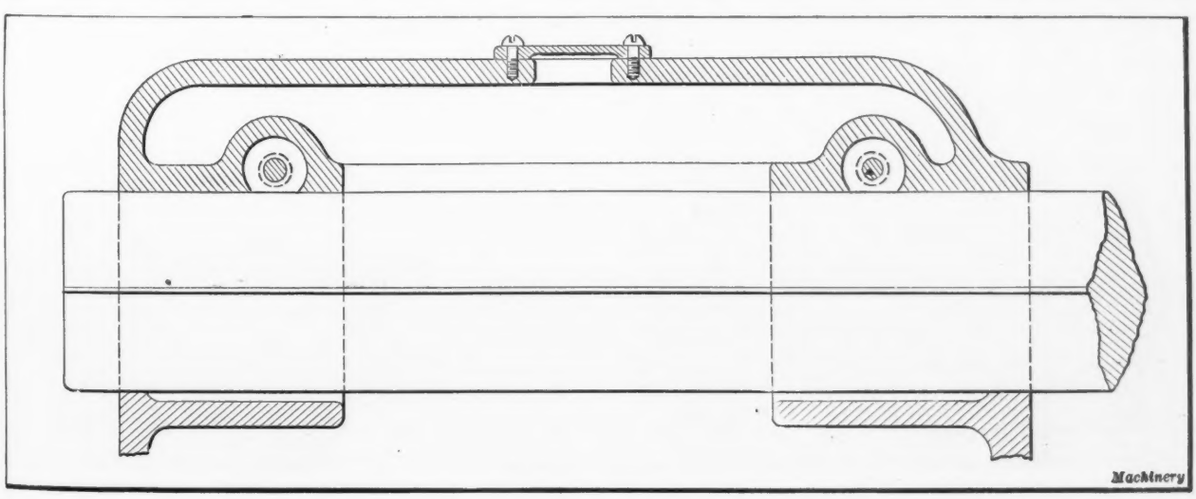


Fig. 16. Square Over-arm locked with Pad-bolts

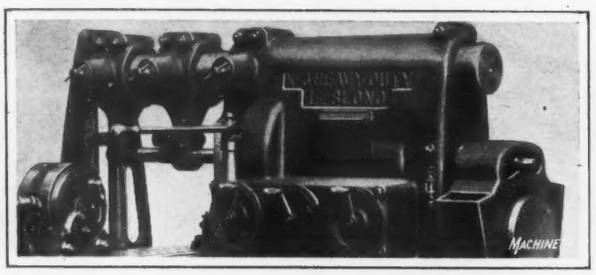


Fig. 17. Over-arm equipped with Wedge-block Locating Devices and Split Clamps

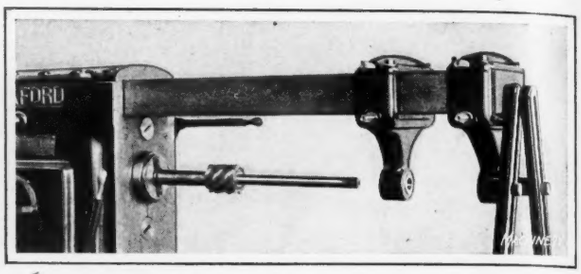


Fig. 18. Over-arm extended to move Arbor Supports and Braces out of the Way

ports, but the column head is left solid, and two shaped blocks fit into openings at back and front, the front block being shown in Fig. 14. The sectional appearance is as shown in Fig. 13, here it will be seen that a spring is provided to lift the block when the nut has been loosened. After the clamps have been bored, their flat bottom faces are tooled off 1/16 inch, so as to prevent contact with the mating face in the head, and thus provide for the clamping action.

In the trend now noticeable in more than one instance of endeavors to get away from the cylindrical over-arm, we find examples of square or oblong section arms, and also cast arms of box section. Any of these arms possessing flat sides, or V-slide guidance, solve the difficulty of alignment easily, and obviously the capacity to resist deflection and torsion is increased. Possibly what has delayed the more extensive introduction of such arms has been the ease of machining the cylindrical arm accurately and of boring out the receiving holes.

The Clarke-Mesker Co. in its Cleveland millers places a square arm cornerwise (Fig. 16); it is held in the column by a cap having 90-degree V-grooves which mate with similar grooves on the column. The cap is aligned through dowel-pins and a taper gib. Two clamping members grip the over-arm; each member comprises two cylindrical parts with beveled surfaces that contact with the arm. These parts are drawn together by a screw extending to the outside of the column. A similar method is followed for the arbor supports. Self-alignment and avoidance of twisting are alike insured.

In addition to the cylindrical arm of the Rockford machines (see Figs. 3, 5, and 7) this firm has a large 4½- by 9-inch cored cast-iron arm for its heavy models. This is scraped in alignment with the main spindle, which makes it very convenient for the operator to line up the work on the table, either from the side or the top of the arm. One such application appears in Fig. 10, where an indicator is shown mounted on a gage-block bearing against the top of the arm, to determine whether the face of the work is parallel with the spindle. Fig. 18 shows how this arm may be extended to move the arbor supports and braces out, when it is necessary to change cutters or work, thus avoiding any need to actually remove these parts. The operator works a handle, the result of which is to turn the pinion *A*,

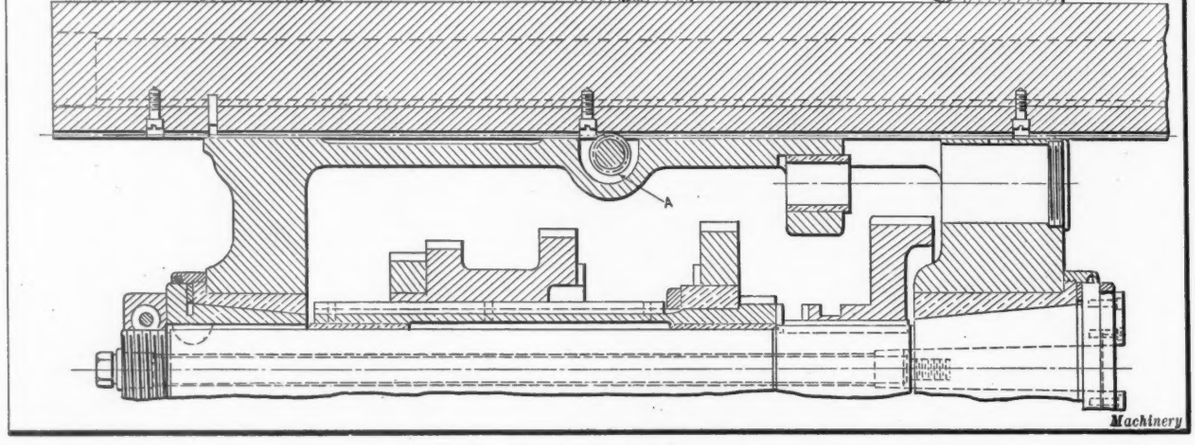


Fig. 19. Over-arm of Rectangular Design

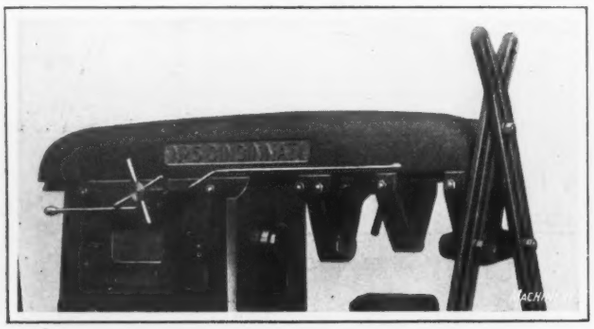


Fig. 20. Design in which the Cast Over-arm is fitted in V-slides

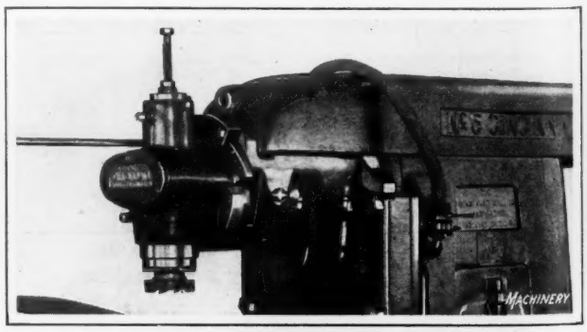


Fig. 21. Vertical-spindle Attachment clamped to Over-arm

Fig. 19, and thus actuate the rack that is screwed to the under side of the arm. The arm slides in the column and under a cap dovetailed to it, and the clamping is performed by two eccentrics (see also Fig. 23), partly rotated by a handle on their squared ends. Each arbor support also carries the same kind of adjustment by rack, and there is one similar eccentric lock for each.

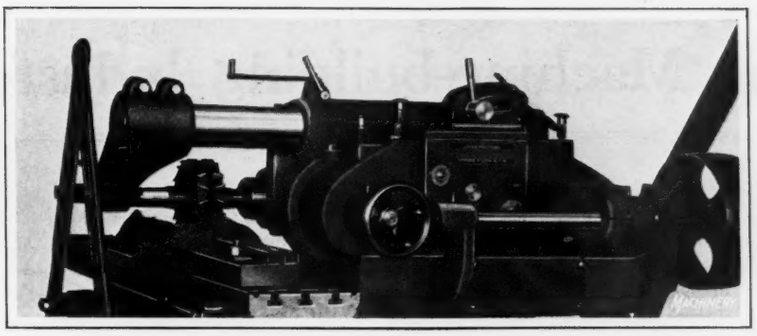


Fig. 22. Arrangement of Arm when Spindle is located in a Horizontal Position

Fig. 24 shows a cross-sectional view of the arm on the high-power machines of the Cincinnati Milling Machine Co., which is fitted by V-guides for the purpose of alignment, and adjusted to and fro by means of a star wheel and pinion. Two bolts effect the clamping (Fig. 20) while the arbor supports also are clamped by cross-bolts, which contract the split castings on the V-edges of the arm. This design is very rigid. Some of the attachments on the Cincinnati millers are not supported by the over-arm, while others (such as the spiral attachment) require the support of the arm and one arbor support. For the vertical attachment, a more rigid arrangement is used; in this case, besides bolting to the column face, the body casting fits and is clamped to the vees of the arm, thus obtaining the maximum support against vertical deflection, and lessening the risk of chatter. This attachment is seen in Fig. 21.

Machines with ordinary cylinder arms generally utilize these in one way or another to clamp various attachments. Often a simple large eye or pendant hangs down and provides a bearing for the neck of a spindle box; or the box itself is made with an eye and clamping device at the top, to grip on the arm. The duplex miller manufactured by the Van Norman Machine Tool Co., contains provision for adjusting the spindle to either a horizontal, vertical, or angular position. In this way a great variety of milling may be accomplished without the use of attachments, and the over-arm does not come into use except in certain cases. For the ordinary use of an arbor in the horizontal position, the arm projects as usual and carries the support at the end (Fig. 22). With the spindle set vertically, the over-arm is advantageous to compensate for the overhang of the head ram (which has an adjustment of 11 inches) as shown in Fig. 25. For extra heavy cutting, the arm can be used to support the ram in its extended position, but this is not necessary for ordinary cuts. The over-arm must also be supported when vertical cutting is done a long distance away from the face of the column, as in Fig. 26, where a sub-head has been mounted on the end of the main cutter-head, and the arbor support sustains the outer end of this head.

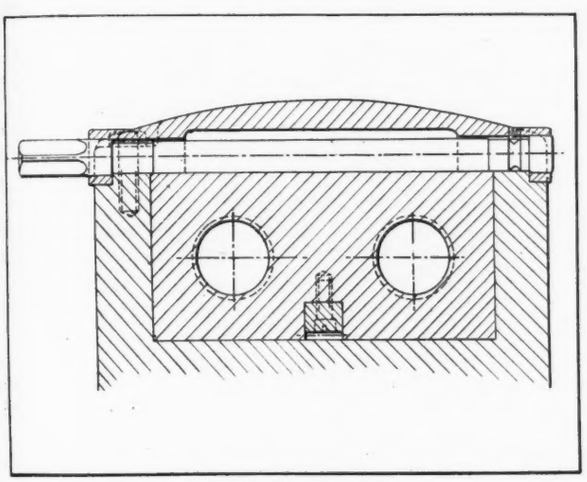


Fig. 23. Over-arm clamped by the Use of Eccentrics

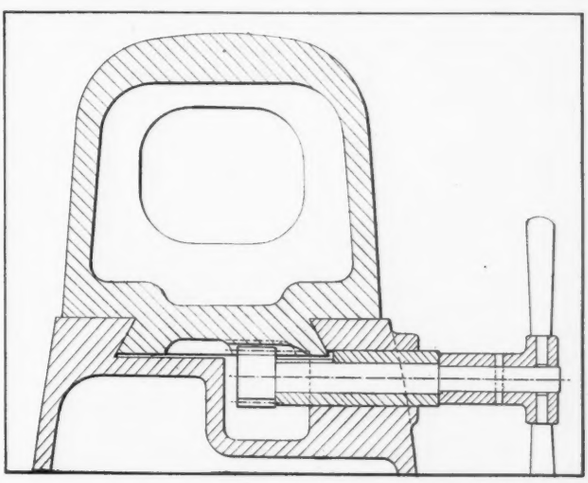


Fig. 24. Rack Adjustment for Milling Machine Over-arm

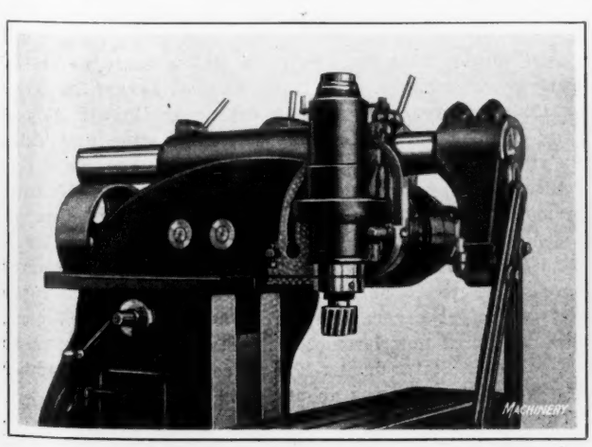


Fig. 25. Over-arm supporting the Spindle in a Vertical Position

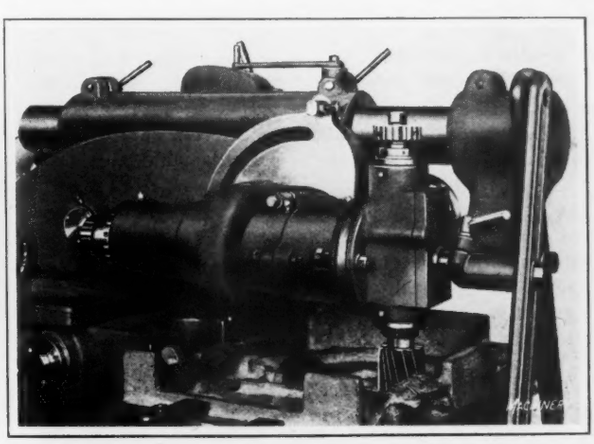


Fig. 26. Sub-head supported by Over-arm and Arbor Support

The Machine-building Industries

WHILE the new year has not yet been characterized by any unusual activity in the manufacturing industries, the steady improvement in general business conditions that began in the early fall of the past year is continuing. Production of basic commodities remains at about the same level as during the latter months of 1924. The decided increase in activity that took place at that time in the iron and steel industry, as well as in cotton and woolen textiles, continues, and there has been a further slight rise in the general price level, reflecting advances in nearly all groups of manufactured commodities. Gradual increases in production are likely, but it is believed that the industrial plants of the country, in general, will be able to supply the demand of the coming peak in production without expansion. Hence, the market for new manufacturing equipment will be mainly for machinery, tools, and appliances that will replace obsolete equipment.

The Machine Tool Industry

The increase in general business activity has hardly made itself felt yet in the machine tool industry, although manufacturers in the small tool and accessories field state that their hopes for better business have already materialized in actual orders. Many machine tool builders have also experienced a gradual, although moderate, improvement during the last three or four months, and several railroad orders of fair size have recently been placed. One of the leading automobile builders has ordered a fairly large volume of machine tools of different types, and several other automobile plants have placed scattered orders for the replacement of obsolete or worn-out equipment. A year with a fairly even demand, rather than one of sharp peaks and valleys, is generally expected in the machine tool field.

In the sheet-metal stamping field, the conditions vary considerably according to the line of manufacture and the locality of the plants. One of the largest sheet-metal stamping concerns in the East has been operating at only about 50 per cent of capacity for the last four years, and at times only at 25 per cent capacity. In this field it appears that the production capacity of the country is at least double the demand, except in the Detroit district, where the automobile industry keeps most of the plants busy.

The Iron and Steel Industry

The conditions in the iron and steel industry indicate an active year in most of the metal-working fields. The market has remained strong and steady, with a stiffening in prices. The mills are operating, if not to capacity, at a very high percentage of capacity. Railroad buying remains active, and on the whole, the industry has a sufficient amount of orders booked ahead to assure the present rate of operation for at least three months. The pig iron market is active, and a record iron ore output in 1925 is predicted. Pig iron producers generally consider that further price advances are justified because of present manufacturing costs.

The active buying of the railroads is of great significance. The railroads use nearly one-third of the steel output of the country—directly or indirectly. It would materially help to eliminate the peaks and valleys in the iron and steel industry if railroad orders could be placed with greater regularity. The orders recently placed by the railroads will create almost a boom in certain fields catering to the needs of the transportation system.

The steel trade has practically adjusted itself to the new pricing system, and despite the confusion caused by the inauguration of the new methods, steady improvements are noted in market conditions. It is a long time since the steel industry faced such a process of readjustment of settled practices as it did during the latter months of the past year, as a result of the agreement of the United States Steel Corporation to comply with the orders of the Federal Trade Commission to abandon a time-honored system of quoting steel prices on a common Pittsburg base. This action introduced a new basis of competition and brought about much uncertainty and confusion and many complications.

The Automobile Industry

In the automotive field normal activity, at least, is expected during the next six months. The industry as a whole is in a better position now than it was a year ago. The mistake then made of over-estimating the production schedules for 1924 is not likely to be repeated. Some stocks will be accumulated for spring demand, but not in sufficient quantity to cause such a slowing down of production as occurred last spring. The price reductions just announced are likely to stimulate the market to some extent.

An important branch of the automotive industry in the future will be the building of buses. It is stated that about 1600 bus lines were started in this country during 1924, and figures compiled by *Bus Transportation* show that the total number of buses purchased during the year exceeded 8000, at a cost of approximately $45,000,000. The production of buses in 1923 was about 6000.

The total production of passenger cars in 1924 was 3,280,000, and of trucks 370,000, a decrease of about 10 per cent below the record production in 1923, but an increase of 38 per cent over the production in 1922. Of the cars built, about 40 per cent were closed cars. The total wholesale value of the passenger cars reached nearly $2,000,000,000, and of the trucks, nearly $300,000,000. Forty-five million tires were manufactured at a wholesale value of $625,000,000. The wholesale value of parts and accessories, exclusive of tires, is estimated at about $875,000,000. The number of people employed in the automotive industry is estimated at over 3,000,000. The average retail price per car in 1924 was $814, and of trucks $1026.

At the end of the year approximately 15,200,000 cars and 1,800,000 trucks were registered in the United States, this being 87 per cent of the total number of motor vehicles in use throughout the world. The export business in automobiles during 1924 was very satisfactory and exceeded considerably the business in 1923. The exports amounted to about 10 per cent of the total production.

The Railroad Situation

There is a practically unanimous agreement among those who used the railroads during 1924, both for passenger and freight service, that the service in that year surpassed all previous performance. The traffic handled during the latter months of the year was record-breaking, the largest volume being handled during October; but even since that time, the rail traffic has broken all records for the respective months. The year ended with a brisk buying of cars, locomotives, and other equipment. The substitution of larger cars and locomotives for retired equipment continues. From 1908 to 1923 the average tractive power of locomotives increased from 26,356 pounds to 38,835 pounds, and the average freight car capacity from 34.9 tons to 43.7 tons. The number of new locomotives installed on the railroads in the United States during 1924 exceeded 2000; the number of new freight cars was about 160,000.

The likelihood that the railroads may be permitted to develop unhampered by restrictive legislation for a few years gives promise of considerable buying activity.

New Machinery and Tools

The Complete Monthly Record of New Metal-working Machinery

Sundstrand Semi-automatic Bushing Turning Lathe

A DOUBLE-SPINDLE semi-automatic machine developed for turning parts made from brass, bronze, aluminum, and other materials that should be worked at high rotative speeds, has recently been developed by the Rockford Tool Co., Rockford, Ill. This machine is intended for parts that can be held by an expanding spring chuck or a spring collet. The spring chucks open and close automatically, so that work can be inserted and removed without stopping the spindles, thus enabling high production rates to be attained. Also, particular attention has been paid to locating all control levers within convenient reach of the operator, and for the same reason, the spindles are placed toward the front of the machine.

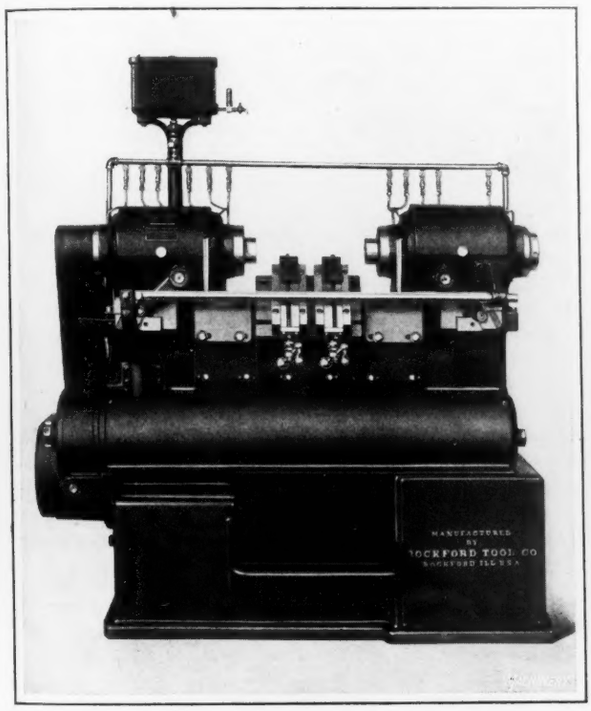


Fig. 1. Sundstrand Double-spindle Semi-automatic Lathe for turning Brass, Aluminum, and Similar Metals

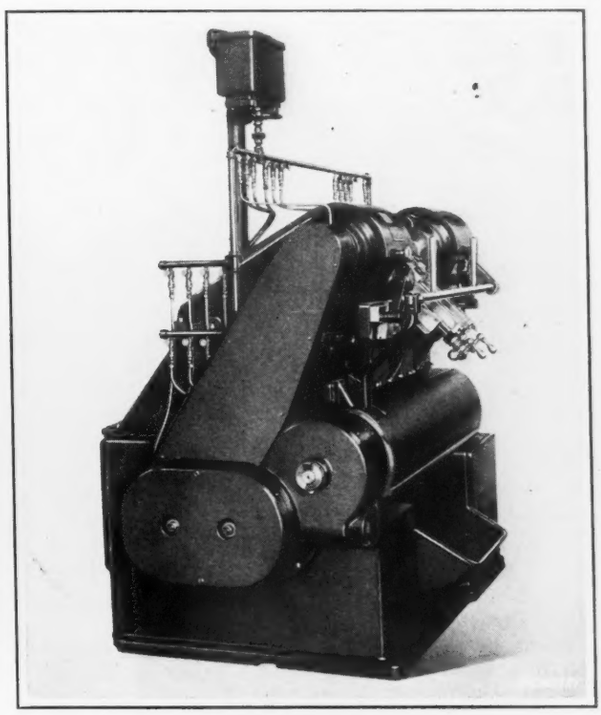


Fig. 2. View of the Semi-automatic Bushing Turning Lathe taken from the Left-hand End

The base is a one-piece casting with wide bearing surfaces for the two headstocks. The carriage is extra long and covers the entire length of the carriage ways, eliminating the possibility of grit and chips getting on the ways. There is a compartment in the lower section of the base for chips, which may be readily cleaned out at the front, and there is also a compartment for the motor starter which is accessible through a door at the front of the base. Still another compartment at the rear of the base contains the motor, which is equipped with two pulleys for driving the spindles. The motor is protected from chips and dirt by a screen housing that permits proper ventilation. For machining parts that must be revolved at a slower speed than is practicable for brass and other soft metals, a single-end motor and a special countershaft of ball bearing construction are supplied to give a reduced spindle speed.

On the regular machine, the drive from the motor pulleys to the two spindles is transmitted by belts. Power is taken from the left-hand spindle for feeding the carriage, the power being transmitted through a belt to the gear-box below and then to a feed-cam drum located directly under the carriage. Loose change-gears give a wide range of feeds. Two tool-holder slides are mounted on the carriage, each holder being provided with an in-and-out adjustment for the tools. This adjustment is accomplished by means of a screw and micrometer dial. The length of travel of the carriage or tool-holder slides depends, of course, on the part to be machined.

The carriage is traversed from one spindle to the other at any required feed by a suitable arrangement of the cams on the feed-drum. These cams can be arranged to give a coarse feed for rough-turning a bushing, and a fine feed for finishing the bushing on the return stroke, and then to traverse the carriage rapidly over to the other spindle for completing a bushing while the first spindle is being reloaded. The spindles are made of high-carbon steel, hardened, ground, and lapped and fitted in taper bearings that may be adjusted for wear by means of a single nut at the rear of each spindle. Lubrication is obtained from a large oil reservoir located above the left-hand spindle and connected by piping to all bearings. There is an individual sight-gage and valve in each pipe line.

Some of the important specifications of the machine are as follows: Maximum diameter of work that can be turned, 6 inches; maximum length that can be turned, 3 inches; maximum travel of carriage, 7 inches; distance between spindle flanges, 15 inches; capacity of driving motor, 5 horsepower; floor space occupied, 40 by 60 inches; and weight of machine, about 3735 pounds.

Circular Dividing Machine made by the Societe Genevoise d'Instruments de Physique

SOCIETE GENEVOISE CIRCULAR DIVIDING MACHINE

A new type of circular dividing machine has been brought out by the Société Genevoise d'Instruments de Physique, Geneva, Switzerland, for whom the R. Y. Ferner Co., Investment Bldg., Washington, D. C., is the American agent. This machine, which replaces the No. 0067, is of a bench type, built more substantially than the previous model, and especially adapted to manufacturing uses. The guaranteed accuracy is plus or minus 6 seconds.

A cross-beam, which is adjustable for height, supports the tracing tool, and the latter is adjustable so that graduations may be ruled on plane, conical, or cylindrical surfaces. Three ratchet wheels of 20, 24, and 32 teeth, respectively, are provided for the tracing tool, as well as nine disks which control the length of lines. One of these disks is plain, and the other eight are arranged in four pairs having 8, 10, 12, and 16 notches, respectively. There are also five ratchet wheels of different numbers of teeth for the worm which operates in the teeth cut around the edge of the circular table. With these provisions, it is possible to obtain practically any style of graduation.

The table is fitted with an inlaid silver strip ruled in sixths of a degree. A locating microscope is provided for reading this scale in making a special setting or in testing work already done. The driving pulley, through a speed reducer, delivers power to a crankshaft which, in turn, drives the worm and tracelet. There are 720 teeth around the periphery of the table and so one revolution of the worm advances the table ½ degree. A 0.15-horsepower motor will drive the machine. The maximum length of line that can be made is 1 inch, the thickness may vary from 0.004 to 0.06 inch, and the maximum depth of line is 0.04 inch. From 10 to 30 lines may be ruled per minute. The height of the machine is 28 inches, and the weight about 365 pounds.

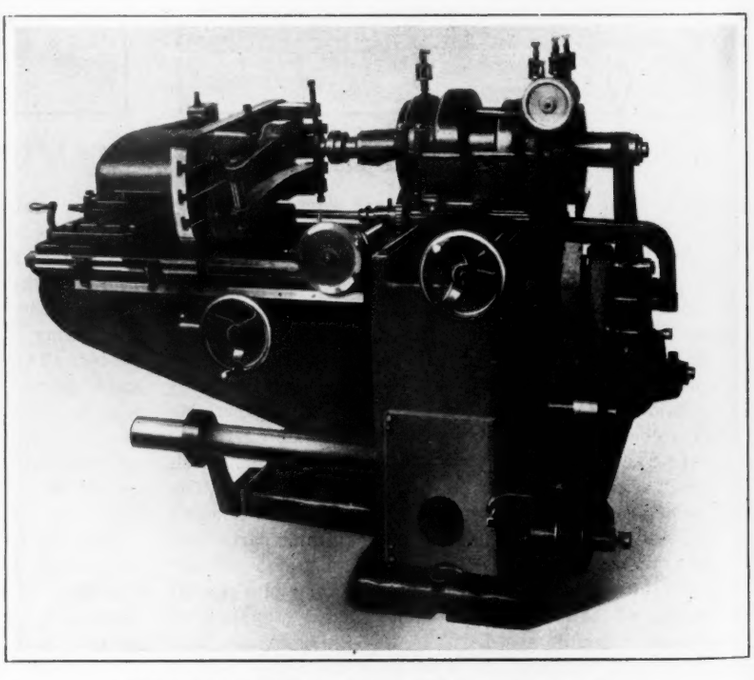
GISHOLT INTERNAL AND LINK GRINDER

The internal grinding machine built for several years by the Gisholt Machine Co., 1300 E. Washington Ave., Madison, Wis., for grinding holes in locomotive parts, has recently been equipped with an attachment that adapts it to the grinding of links and link blocks. This attachment is intended to make the machine suitable not only for large railroad shops, but also for comparatively small shops that do not have enough internal and radius grinding to justify the purchase of two separate machines. The link or arc grinding attachment is mounted on the regular table, and consists of a cross-slide table, in the center of which is a pivot carrying a cradle that is free to rock. A rail pivoted in the same horizontal plane as the cradle pivot and having an angular adjustment in the vertical plane controls the rocking motion of the cradle as the cross-slide travels back and forth.

The grinding wheel spindle is located in the same vertical plane as the rail-pivot and remains fixed in this position so that the combined movement of the cross-slide and the cradle produces an arc tangent to the grinding wheel. The center of this arc is on a line perpendicular to the cradle and through the center of its pivot. Any desired radius of arc may be ground by adjusting the rail angularly according to a chart mounted on the attachment.

Power for driving the cross-slide table is taken from the feed-screw that drives the regular table; the feed-screw is provided with a clutch for disconnecting the work-table power feed, so that power movements of the work-table and cross-slide cannot take place simultaneously. However, hand feed is always available for the work-table, so that it can be moved back and forth occasionally to insure even wear of the wheel and a parallel surface. The feed trip and the reverse lever control the reverse motion of the cross-slide table through the regular table trip mechanism, which can also be operated by adjustable trip dogs on the trip disk when automatic reversal is required. In grinding internal arc surfaces, such as those of locomotive links, the work is secured to the fixture plate by means of clamps, but in grinding external arc surfaces, such as those of link blocks, it is preferable to hold the work on a vertical slide attached to the fixture plate. This provides greater adjustment than can be obtained with the knee of the machine.

If the guide rail is set parallel to the movement of the cross-slide, the radius of the arc will be of infinite length, and so the machine can be used for straight surface grinding without removing any part of the attachment. When it is desired to grind straight surfaces on work that cannot be held conveniently on the fixture plate, the cradle can be removed and the work placed on the cross-slide table. Wheels from 2¼ to 2½ inches in diameter and from 3 to 4 inches in face width are used. The hole in the grinding wheel is ¾ inch in diameter. The link grinding attachment weighs about 500 pounds, while the total weight of the machine is approximately 3100 pounds.



Gisholt Internal and Link Grinding Machine for Railroad Shops

BULLARD FOUR-SPINDLE "MULT-AU-MATIC"

An 8-inch four-spindle "Mult-Au-Matic" is being introduced to the trade by the Bullard Machine Tool Co., Bridgeport, Conn., for such work as does not require the variety of machining operations that can be performed on the six-spindle "Mult-Au-Matic." The machine, as shown in Fig. 1, comprises four individual production units, under an automatic centralized control. The work-holding spindles are mounted in a revolving carrier, and four stations are provided about the central column. There are no tools at the first station, and the work-holding spindle stands idle at this station to permit the operator to unload finished work and chuck a rough piece. The second, third, and fourth stations are provided with universal tool-carrying heads which may be set independently as regards speed and feed, to suit the requirements of the work.

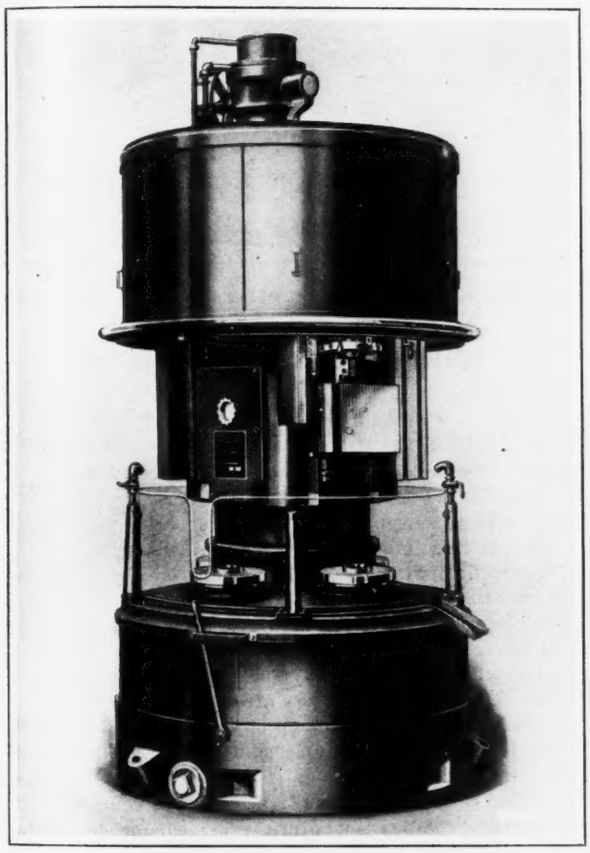


Fig. 1. Bullard Four-spindle "Mult-Au-Matic"

When sufficient tooling capacity is not available for certain work by the use of the three main heads alone, a supplementary side-head may be mounted at the stations, as shown in Fig. 2. Thus it is possible to employ six separate heads for machining any piece of work. This side-head unit is mounted on a bearing on the central column, and is braced by an arm extending across the face of the column. The tools are held in standard or special holders clamped to the face of the tool-slide. Vertical adjustment of the side-head is made by hand to suit each job, and horizontal, vertical, or angular cuts may be taken. The traverse of the side-head ranges from 3 to 6 inches. The total distance is made up of components of the rapid traverse and the feed, the proportions and rates of which are in direct relation to the main head at the same station.

The cycle of operations begins with the indexing of the carrier and the presentation of new work at each station. All tool-heads advance rapidly to the point of cutting at a constant rate which bears no relation to the feed. Then, at a predetermined point, the rapid traverse is stopped and the feed engaged. When the work is completed, the tools and heads are returned by the rapid traverse, and as the last head to complete its work returns, the indexing mechanism is automatically tripped and the cycle repeated. The time of a cycle is limited only by the time required for the longest single step. The rated capacity of the machine is for work up to 8 inches in diameter and 6 inches in height, but it will swing work up to 12 inches in diameter. The machine is 10 feet 8 inches high, and occupies a floor space 5 feet 7 inches in diameter.

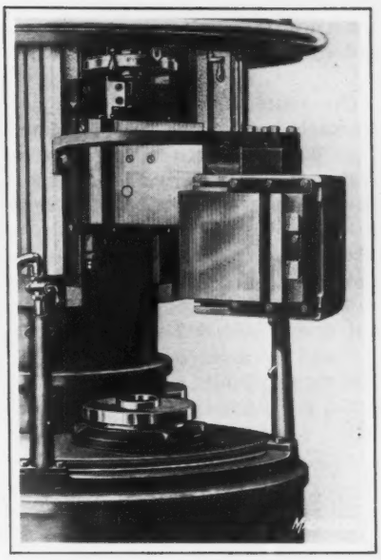
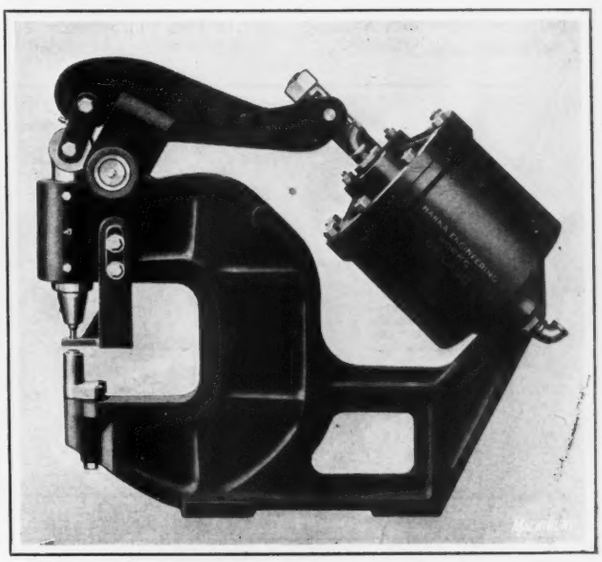


Fig. 2. Working Station equipped with the Universal Main Head and the Supplementary Side-head

HANNA COMBINATION RIVETER AND PUNCH

The latest development of the Hanna Engineering Works, 1763 Elston Ave., Chicago, Ill., is a pneumatic combination riveter and punch, for which high-speed operation and wide adaptability are claimed. The machine can be mounted either on a bench or a special stand in an upright position as shown, or cradled in an inverted position. It can also be suspended for portable use with the dies vertical or horizontal. The machine is particularly recommended for use in automobile shops on work that otherwise would be hard to reach. It may be equipped with special tools for crimping wire, upsetting operations, etc.

The cylinder is equipped with an air cushion feature at each end to absorb the inertia of the rapidly moving piston at the ends of the stroke. The cushion at the working end of the cylinder is essential in the use of the machine as a punch, as the high air pressure built up below the piston to force the punch through the work must not be permitted to force the piston against the cylinder head at a high velocity when the resistance is suddenly released. A combina-



Hanna Pneumatic Combination Riveter and Punch

tion simple lever and toggle mechanism produces a long die stroke that has a considerable zone of uniform pressure and eliminates the necessity of a screw adjustment on the die.

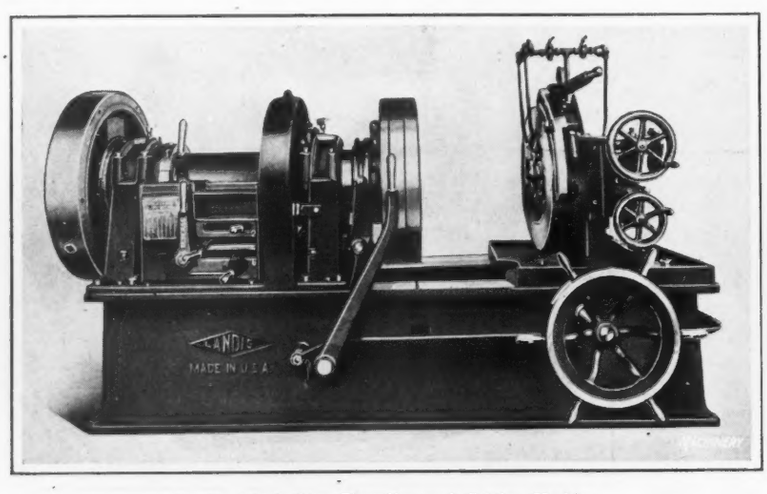
The upper part of the die stroke is rapid until the die approaches either the rivet or plate, when the speed gradually decreases until the last few inches of piston travel, during which the speed is considerably reduced and uniform, the pressure also being uniform. Ordinary variations in length of rivets and thickness of plates are automatically taken care of. Three sizes of this machine are built having a gap of 7, 8, and 9 inches, respectively, and a rated capacity of 6, 10, and 15 tons, respectively. The smallest machine will drive hot rivets up to ¼ inch, the intermediate size 5/16 and ⅜ inch, and the largest size 7/16 and ½ inch. Cold rivets, slightly smaller, can also be driven. The weight of the machines is 300, 450, and 625 pounds, respectively.

LANDIS PIPE THREADING AND CUTTING MACHINE

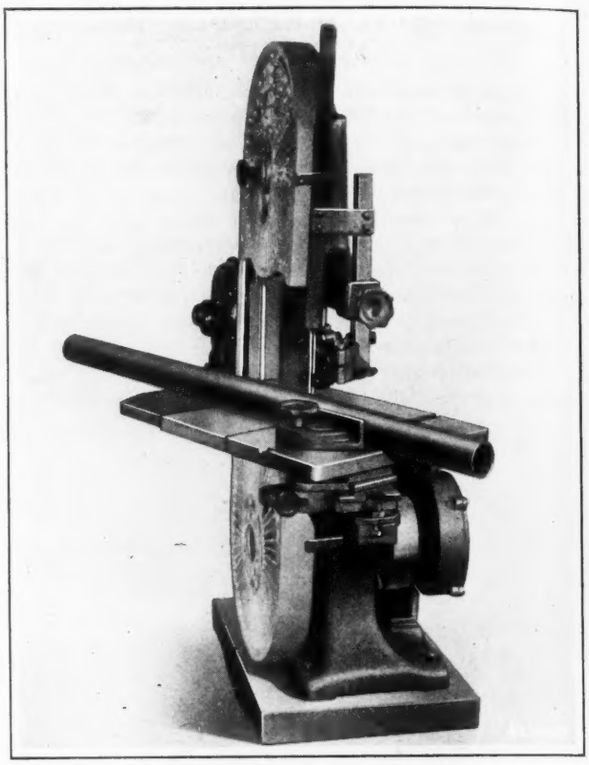
A machine that accommodates work from 1 to 6 inches in size, inclusive, has been added to the line of pipe threading and cutting machines built by the Landis Machine Co., Inc., Waynesboro, Pa. Two die-heads are employed for covering the range of work, a 2-inch head for 1- to 2-inch work, inclusive, and a 6-inch head for 2½- to 6-inch work. The entire range of each head is covered by one set of chasers. Although the illustration shows a belt-driven machine, motor drive can also be provided, in which case the motor is mounted on a plate at the rear. Eight speeds are obtainable by means of a self-contained gear-box beneath the main spindle. All the gears run in oil. The shaft bearings in this box are lubricated by a forced-feed system, and the main bearings by flat-link chains which carry oil from large reservoirs.

There is a universal adjustment for the front chuck, and this chuck is lever-operated to permit gripping and releasing the pipe while the chuck is in motion. At the rear of the machine, a universal geared chuck is furnished, which is fitted with grips for screwing flanges on and off. A reverse drive for putting on and taking off flanges is obtained by shifting a lever. The die-head is supported by the cross-rail, which is also fitted with cutting-off tools, a reaming tool, and a length gage.

The motor drive can be applied after a machine is in service. In this type of drive, a silent chain transmits power from the motor to the machine. A 7½-horsepower constant-speed motor, wound for a speed of about 1200 revolutions per minute, is required. The machine employs the stationary die-head and "Long-life" tangential chaser made by this company. It is 9 feet 8 inches long, 4 feet 10 inches wide, and weighs about 8800 pounds.



Landis 6-inch Pipe Threading and Cutting Machine



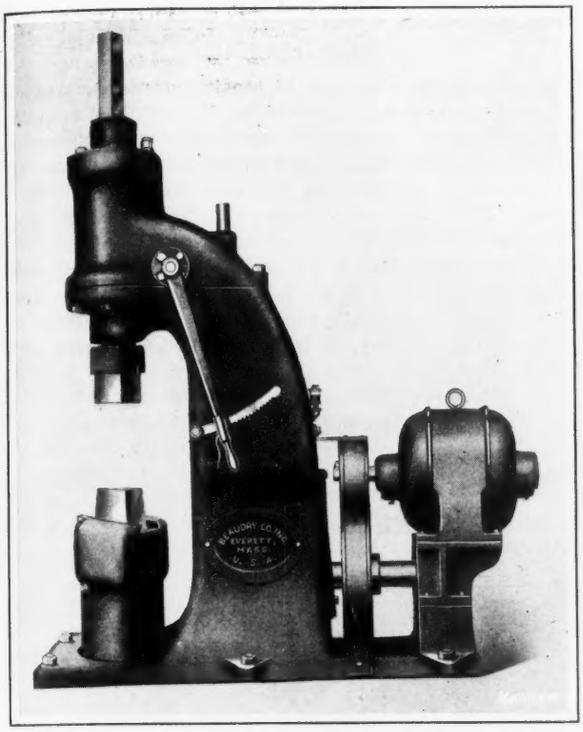
Racine Duplex-speed Band Saw with Swiveling Feature for Table and Saw Guides

RACINE DUPLEX BAND SAW

Work of any length may be handled on a new model duplex band saw brought out by the Racine Tool & Machine Co., 250 Fifteenth St., Racine, Wis., in which the table and saw guides can be swiveled so as to direct the saw blade at any angle. This machine is built for sawing wood, soft metals, iron, and steel. There is a roller guide mounted on the table column immediately below the cutting point, this guide swiveling with the table. There is also an upper guide mounted on the regular guide post which is capable of being swiveled about the blade. Thus the blade is supported immediately above and below the work so that a straight cutting edge is always presented to the work, regardless of the amount of twist given to the blade.

The swivel guides are made up of two small rollers which support the blade on each side, and a larger roller which supports the blade at the rear and takes the feeding pressure. These rollers are hardened, ground, and equipped with ball bearings. Adjustments are provided for horizontal alignment of the guides and for width and thickness of the blades. These adjustments are made through thumb-screws and handwheels.

Cutting of a large variety of materials and shapes at the proper speed and with the correct blade is made possible by the incorporation of the "duplex" or change-speed feature which was described in connection with a machine illustrated in December, 1922, MACHINERY. It is to be understood, of course, that the machine can be used for straight cutting on ordinary work. The table and saw guides may also be adjusted minutely to compensate for faulty brazing or inaccuracies made in filing and setting. Such variations often cause the blade to crawl and make it difficult to use a fence or guide in cutting multiple pieces into parallel strips. By directing the blades slightly to the right or the left such crawling can be overcome, so that straight cuts of any length can be taken.



Beaudry Air Hammer which is built in Six Sizes, arranged for either Belt or Motor Drive

BEAUDRY AIR HAMMER

A line of air hammers in six sizes, equipped with rams weighing from 100 to 1200 pounds, is being introduced on the market by the Beaudry Co., Inc., Parkway at Vine St., Everett, Mass. The average size of work for which the machines are intended ranges from 2½ to 8 inches, while the number of strokes per minute ranges from 220 in the smallest machine to 110 in the largest. Either a belt or motor drive can be furnished. When equipped with a belt drive, no countershaft is necessary, as tight and loose pulleys are mounted directly on the machine, the belt being shifted to the loose pulley only for long stops. With a motor drive, a 5-horsepower motor is furnished on the smallest machine and a 40-horsepower motor on the largest.

The blow is regulated from a light sensitive tap to a heavy blow, by means of the foot-treadle, the ram being held suspended when not working or clamping work for bending. Bars of any length may be worked either way of the dies. The ram is of such design that the greater part of its weight is concentrated in a bar of large diameter, and it is guided by passing through both the upper and lower cylinder heads. The head is separate from the bar, and hence is readily removable when it is required to remove the ram from the cylinder. A wedge clamping ring is employed to attach the head to the ram. The latter is entirely cushioned by air. These machines weigh from 5000 to 34,000 pounds.

BIRDSBORO PLATE PLANING AND UPSETTING MACHINE

"Lock-bar pipe" is the name given to a pipe made up from plates that are first planed and upset along two edges, then rolled to the proper diameter and finally made leakproof by pressing a special rolled lock bar over the upset edges. One end of each pipe section is smaller in diameter than the other end to permit fitting sections into each other. Because of this feature the upset edges of the plates are not parallel. For planing and upsetting these plates, the Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa., has recently built the machine illustrated, which handles plates 30 feet long and from 12 to 30 inches wide. The machine was built for the Riter-Conley Co., Pittsburg, Pa.

The machine consists of two main beds 45 feet long, which carry lead-screws and carriages. Each side of these beds is formed into a beam on which the plates rest, and above these beams are two clamping girders which apply a hydraulic pressure of approximately 50 tons to hold the plates securely for the full length of the edges to be planed and upset. The clamping girders, in turn, are supported by two overhead cross-beams that rest on columns.

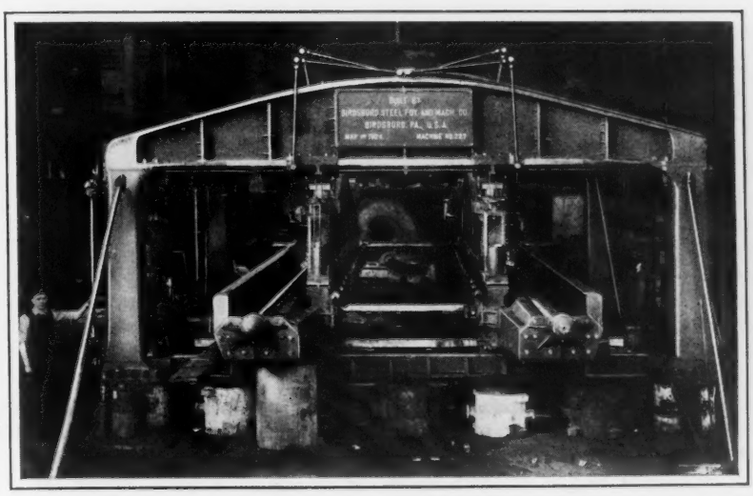
The two lead-screws are 6 inches in diameter, have triple threads, and are connected by bevel gears to a common shaft which is driven through reduction gearing by a 200-horsepower motor. Each carriage is equipped with a holder for six tools and a holder for eight vertical upsetting rolls. In front of the carriage is a bar by means of which the finished plate is pushed out of the machine, and at the back of the carriage is a clamping device by means of which an unfinished plate is gripped and moved into the machine.

Because of the plates varying in width, it is necessary to have the position of the beds and clamping girders adjustable. Adjustments are accomplished by means of two single-thread screws mounted below the beds and two mounted below the overhead cross-girders. The four screws are connected by bevel gears to a common shaft which is driven by a ten-horsepower motor. An individual adjustment is necessary at both ends of the beds and girders due to the two edges of the plates not being parallel. These individual adjustments are obtained through two jaw clutches on the shaft that drives the cross-screws.

In an actual test it was found that in upsetting the edge of a ½-inch plate, a pressure of approximately 200 tons was required. In addition to this side pressure on the beds, a considerable stress is produced by the cutting tools. It is sometimes necessary to remove as much as 2 inches of stock from each of the two edges, which is done by the six cutting tools simultaneously with the upsetting. The feed of the carriages is from 25 to 35 feet per minute, depending upon the thickness of the plate. In an actual operation, a plate 30 feet long was planed and upset, removed from the machine, and replaced by another which was also located for the operation, in 2¾ minutes. Plates are removed by using an overhead magnet.

BIAS CENTERLESS BUFFS

Buffing wheels made in such a way that all threads at any point around the periphery run at an angle of 45 degrees with a tangent, are manufactured by the Bias Buff & Wheel Co., 430 Communipaw Ave., Jersey City, N. J. It is because of the threads running diagonally that the wheels are called "Bias." With this construction threads cannot



Birdsboro Plate Planing and Upsetting Machine

Fig. 1. Cloth Section of a Bias Centerless Buffing Wheel

fly off, and so they all whip the work as the wheel is rotated. The claims made for this line of buffing wheels are that they have a long life, exact less physical effort from the operator, remain balanced, and considerably reduce the consumption of tripoli in polishing operations, and the amount of dust and lint produced.

The wheels are made up of sections such as shown in Fig. 1. These sections are placed on flanges in the manner illustrated in Fig. 2, the flanges being made to hold a variable number of sections. For example, a 10-section flange can be used to hold from eight to twelve sections. Each flange is made with machined lugs that fit between similar lugs on the mating flange, and the flanges clamp the cloth securely on each side of the assembled wheel so as to eliminate rotation of the cloth sections on the flanges.

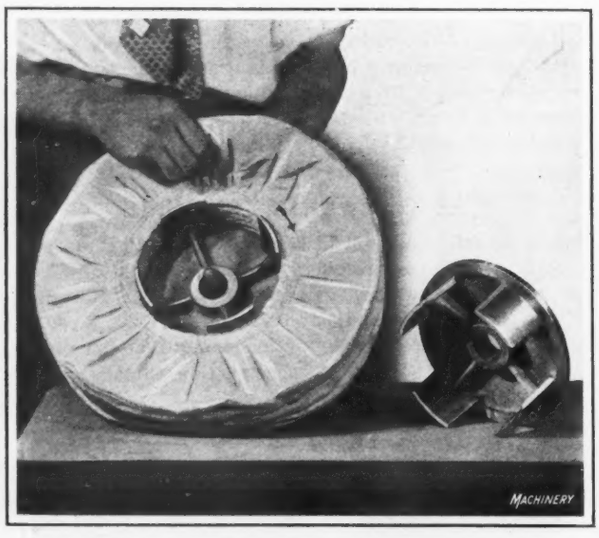


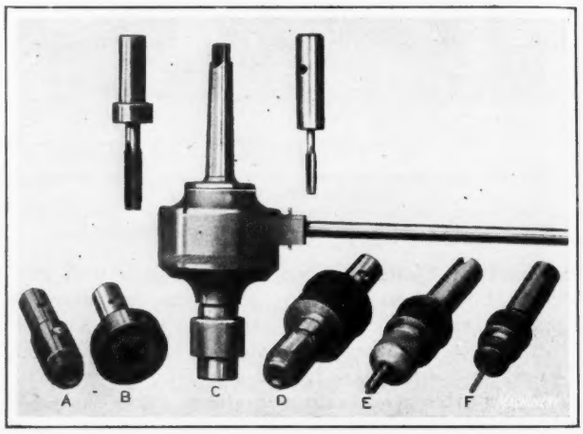
Fig. 2. Assembling the Cloth Buff Sections on the Flanges

In a recent demonstration, a 10-section wheel was placed on a spindle and run at a speed of 2400 revolutions per minute. Ten sections gave a width of 2⅝ inches. While the wheel rotated, the face was raked down, during which time almost no threads came out and little or no lint or dust emerged from the wheel. When properly raked down, the buff has a velvet-like surface similar to that of Canton flannel buffs. It is mentioned that because of the small amount of dust or lint produced, the buffs may be employed without any exhaust apparatus. In polishing radiator shells, they have been especially successful in covering marks or scratches made by the use of a coarse emery wheel in the preliminary polishing.

PROCUNIER QUICK-CHANGE TAPPING EQUIPMENT

For performing a variety of tapping operations rapidly in a single-spindle drilling machine, William L. Procunier, 18 S. Clinton St., Chicago, Ill., has just brought out an attachment supplied with a quick-change chuck that permits the operator to change tools while the machine spindle is running. This attachment is shown at *C* in the illustration When the operator desires to change a tool, he simply lifts the locking collar with his hand, allowing two steel balls to slide out of pockets in the collet so that the collet drops into his hand. A different tool may then be substituted.

Stud setters are also made with either a friction or a positive drive for use with this attachment. The positive-driven tool is shown at *A*, and the friction-driven setter, at *D*. With the friction-driven setter, the stud may be driven to the bottom of a hole, and when the strain becomes too great, the friction device slips so that the stud is not twisted off. Pressure is released from the end of the stud when the reverse motion is applied, leaving the stud firmly set. The positive-driven setter has not a safety friction.

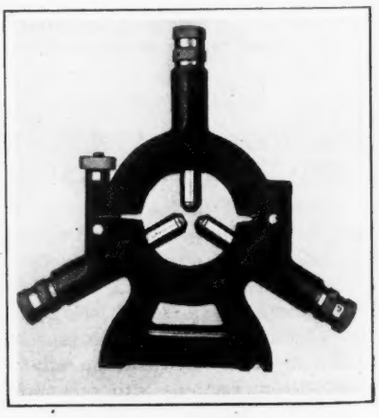


Procunier Tapping Attachment and Accessory Tools

The die-holder shown at *B* enables external threading to be done on drilling machines. A balanced reversing mechanism incorporated in the attachment backs off the die at twice the forward speed. Two friction tapping chucks shown at *E* and *F* may be used with different sized taps for bottom tapping. They are also equipped with a safety friction device that slips when the strain becomes too great on the tap and thus eliminates breakage of the taps. Collets may be supplied to suit requirements.

MULLINER STEADYREST

In an article entitled "Improving the Steadyrest," in January MACHINERY, a reader suggested that steadyrests would be more convenient if knurled-head screws that could be turned by the fingers for adjusting the jaws, were substituted for the square-head set-screws ordinarily furnished. This provision is made in the Mulliner steadyrest, manufactured by the Porter-Cable Machine Co., North Salina and Exchange Sts., Syracuse, N. Y., for use on 12- and 14-inch tool-room lathes.



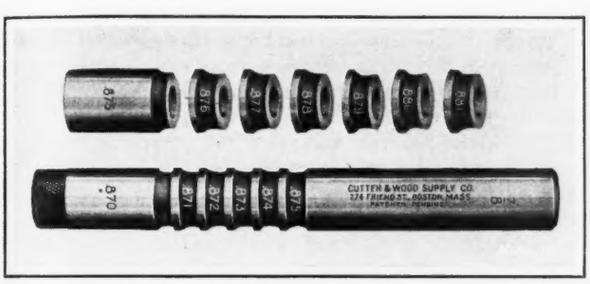
Mulliner Steadyrest equipped with Knurled-head Adjusting Screws

The steel jaws of the Mulliner steadyrest, which is shown in the accompanying illustration, are ⅞ inch in diameter and have a slot milled the entire length to receive a key that prevents them from turning. Each adjusting screw is also provided with a knurled lock-nut that need only be given a quarter turn to lock or unlock the jaw. Inserted tips may be made of brass, bronze, fiber, cast iron, etc.

INTERCHANGEABLE-CUTTER BROACH

Broaches made up of a body, a pilot, and interchangeable cutters are manufactured by the Cutter & Wood Supply Co., 274 Friend St., Boston, Mass. The regular stock comprises thirty-three sizes ranging from ½ to 1½ inches which increase in increments of 1/32 inch. In addition, there is a standard broach for use on Ford automobiles, and cutters can be made special in sixty-fourth inch sizes. In a standard set, an extra pilot and six extra over-size cutters are furnished, so that holes can be broached from 0.001 to 0.006 inch over-size.

In broaching aligned holes where the space between the holes is too great for the regular pilot to function, the cutters may be reversed on the body and the shank of the tool used as a pilot. This tool is intended primarily for use in repair shops and service stations, for broaching connecting-rods, piston-pin bushings, steering knuckles, gears, etc.

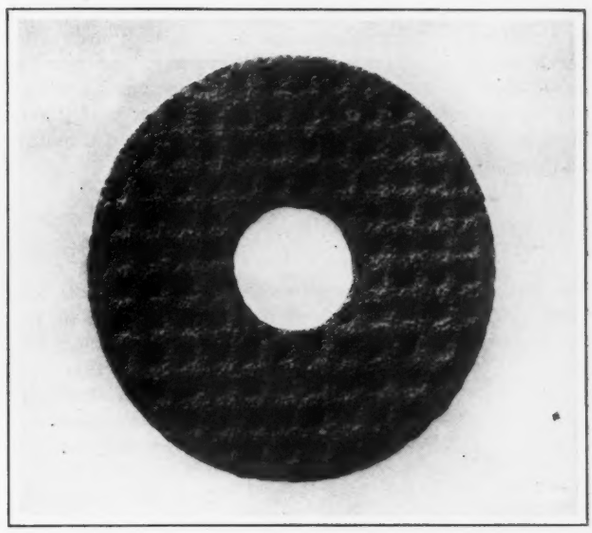


Broach consisting of a Body, a Pilot and Interchangeable Cutters

PEDESTAL FOR COMBINATION TABLE AND VISE

The combination table and vise built in 16- and 19-inch sizes by the Modern Machine Tool Co., 601 Water St., Jackson, Mich., for use with drilling machines, may now be provided with a pedestal as shown in the illustration. The pedestal adapts the appliance for use under a radial drilling machine. It may be set on the side of the machine base on a standard base, or on an individual foundation. It is stated that a machine equipped with a pedestal and combination table and vise, can not only handle all work done on a box table, but in addition has the advantage of a device that may be used both for supporting and gripping work. Projections on work can be taken care of by letting them extend into the opening of the jaws, which permits the work to be laid flat on the table and eliminates the necessity of using parallels for blocking up.

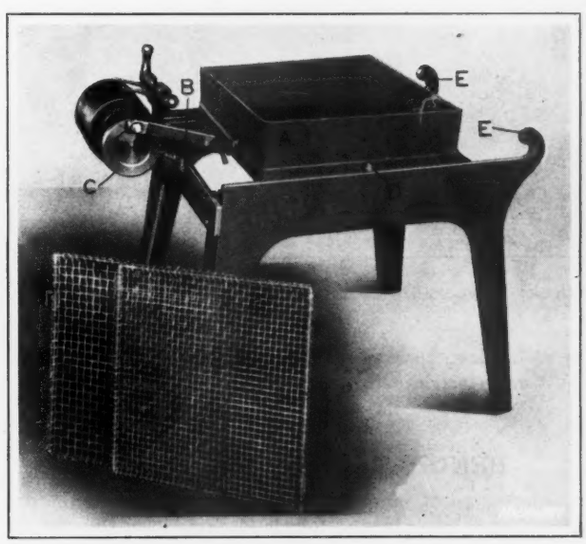
Modern Combination Drill Table and Vise mounted on a Pedestal



Gardner Abrasive Disk with Deep Corrugations

GARDNER DEEP-CORRUGATED DISK

A deep-corrugated "G. I. A." abrasive disk constitutes a recent development of the Gardner Machine Co., 414 E. Gardner St., Beloit, Wis. This disk is especially designed for grinding large surfaces, and is said to prevent the castings from being warped by the excessive heat generated in such operations. The disk surface is corrugated with holes that go practically through the disk to the cloth backing, as shown in the illustration. These corrugations afford plenty of chip clearance during the grinding operation. It is claimed that they enhance the cutting and cooling qualities and that the disk will not glaze.



Sanford Machine for separating Chips from Work

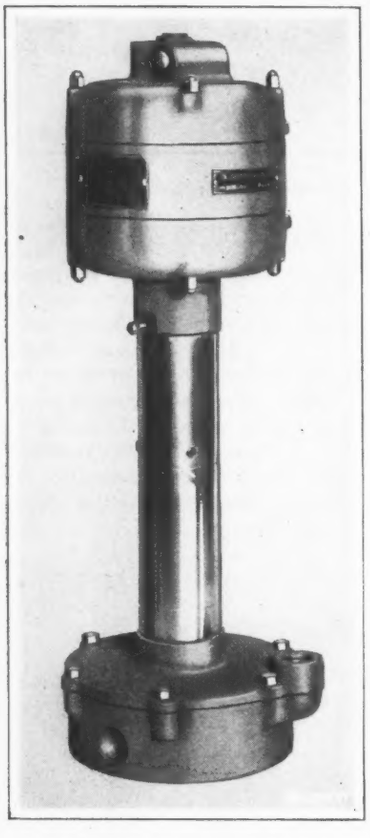
SANFORD CHIP SEPARATOR

Chips may be separated from work and the work conveniently dumped into a receptacle after the operation, by using a machine now being placed on the market by the F. C. Sanford Mfg. Co., 2060 Fairfield Ave., Bridgeport, Conn. The work to be cleaned is emptied into the shaker box *A*, and this box is then reciprocated on the ways of the stand by connecting-rod *B*. The latter is given motion because of being connected off center to disk *C* which is mounted on the driving shaft. At the end of an operation, rod *B* is disconnected and the shaker box moved to the right-hand end of the stand. Here it may be readily dumped, a projection *D* on each side of the box coming in contact with lugs *E*.

This machine is intended for use in combination with an oil separator for separating chips from finished work after the oil has been separated from the work and chips. The shaker box is 24 inches square, 6 inches deep, and is equipped with three screens of ¾, ½, and ¼ inch mesh, respectively. There is ample room under the stand to admit a container for the chips that drop through the screens.

"GUSHER" MOTOR-DRIVEN PUMP

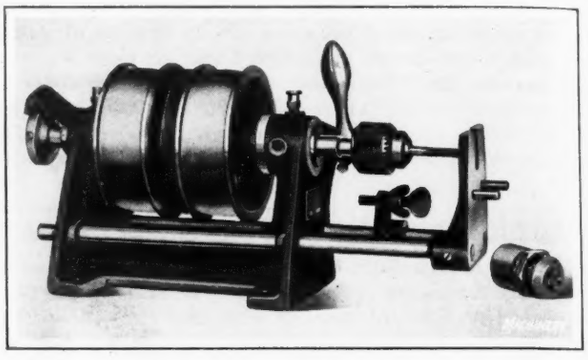
In September, 1924, MACHINERY, a description was published of the motor-driven lubricant pump that had just been placed on the market by the Ruthman Machinery Co., Front and Pike Sts., Cincinnati, Ohio. The pump described was adapted for use only in cases where it could be submerged in the lubricant reservoir of a machine. However, there are many instances where such an installation is impractical on account of interference with machine members, and to meet such conditions, a new motor-driven pump of the design illustrated has been brought out by the same concern. This pump may be submerged in the lubricant or mounted outside of the reservoir and connected by piping. The pump is equipped with ball bearings that are enclosed so that the fluid being pumped is excluded from them. This exclusion is accomplished by maintaining a hydro-static balance in the pump. A range of pump sizes is made to deliver from 3 to 30 gallons of lubricant per minute. The motor can be furnished to suit any electric current.



"Gusher" Motor-driven Lubricant Pump

BENCH TAPPING MACHINE

A bench type of tapping machine is being placed on the market in two sizes by the Bench Machine Tool Co., 220 N. 13th St., Philadelphia, Pa. The No. 2 machine illustrated is of the friction cone type, and has a range of from 3/16 to ⅜ inch in cast iron and from 3/16 to 5/16 inch in steel. Tapping speeds of from 350 to 1000 revolutions per minute can be obtained to suit the material, the size of tap, and the depth of hole. The reversing speed of the tap is usually twice the tapping speed. The machine is equipped with a sliding faceplate which is finished square with the tapping spindle. It is also provided with an easily adjustable stop which automatically disengages the driving cone when the hole has been tapped to a predetermined depth, this being a feature that is especially useful in tapping blind holes. The machine is driven through flanged clutch pulleys by one straight and one crossed belt, from shafts either overhead or below. No countershaft is required, as the machine is equipped with a device that holds the spindle stationary when changing taps or when the machine is not in use.



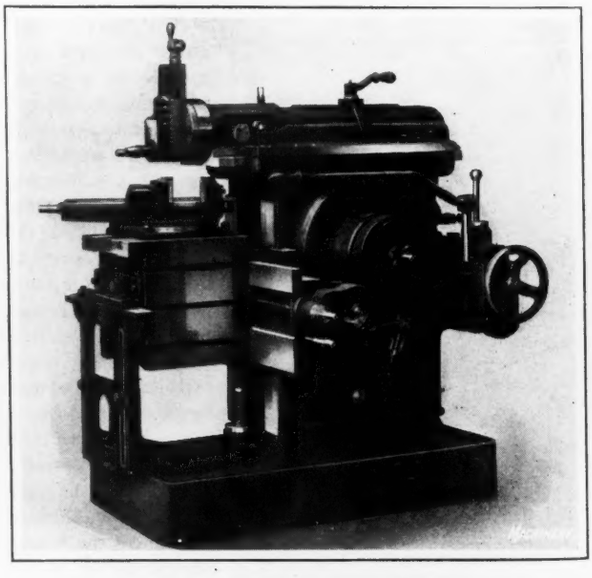
Bench Tapping Machine which may also be used for cutting External Threads

An operation consists merely of placing the drilled work against the faceplate, and with a light push, starting it on the tap. On reaching the predetermined depth, the drive is automatically disengaged, and a slight pull is given to start the tap rotating in the reverse direction. The clutch is so designed that only a light pressure is necessary to drive the tap into the work. In using the larger sized taps, any torque is taken by the steadying pins mounted on the faceplate. Special work-holding fixtures can be attached to the faceplate for quantity production operations.

The machine is also furnished with an adapted and die-head for cutting external threads. The adapter is bored to fit the spindle, and is interchangeable with the Jacobs chuck shown on the machine in the illustration. Another use of the machine is for drilling small parts or for producing shouldered studs by the hollow-mill process. The No. 1 machine is a smaller size similar to the machine described, except that it is designed for using from No. 3 to No. 10 taps. Also, it is equipped with flat friction disks that increase its sensitiveness and prevent the breakage of taps.

STOCKBRIDGE HEAVY-DUTY BACK-GEARED SHAPER

A 16-inch heavy-duty back-geared shaper of similar design to the 32-inch machine described in June, 1924, MACHINERY, has recently been brought out by the Stockbridge Machine Co., Worcester, Mass. This machine is intended for tool-room work of the heaviest kind within its range. The gear-box is of the selective sliding-gear type with an automobile shift and a high-ratio gearing that gives ample power for taking heavy roughing cuts. Four speed



Stockbridge Heavy-duty Back-geared Shaper

changes are obtainable through the gear-box and four more through the back-gears, giving eight changes in all.

The driving clutch is of the automobile type and when the machine is stopped, this clutch is locked against any possibility of starting it up. The clutch is operated through the horizontal lever that extends to the front of the machine. The ram can be positioned by manipulating this lever, and can also be set by hand by simply revolving the handwheel on the right-hand side of the machine.

Cross-feed of the saddle in either direction is obtained by simply throwing a handle to the right or left. Changing of the feed-rod position is not necessary in order to reverse the direction of feed, and neither is it necessary to stop the machine. The feed always operates on the return stroke of the ram. It is mentioned that all driving parts have been designed to withstand any possible strains with the shaper operated at double its rated power. The vise is constructed in such a way as to eliminate overhang of the front jaw and to keep the work as close as possible to the top of the table The vise jaws measure 12 by 2½ inches and open 12 inches. An automatic down feed can be furnished.

"ROTO" PORTABLE PNEUMATIC GRINDERS

A line of portable pneumatic grinders differing from common types in that they do not use pistons for applying the power is being introduced on the market by the Warner & Swasey Co., Cleveland, Ohio, under the trade name of "Roto." Instead of pistons, these grinders are provided with a rotor mounted on the driving shaft, a controlling slide valve, and a valve mechanism. Movements are thus confined to three parts.

From the sectional view shown at *A*, Fig. 2, which is taken transversely through the cylinder of one of these grinders, the operation can be understood. Air enters through the inlet at *C*, a small portion of the air being conducted upward to the air cushion chamber *D* from which it is deflected downward to exert a constant pressure on the upper edge of the valve blade *E*. This pressure maintains a sealing effect between the eccentric surface of rotor *F* and the valve blade, no matter what the position of the grinder may be.

The main portion of the air entering the inlet rushes into the cylinder in the direction shown by the long arrow, and causes the rotor to revolve in a clockwise direction. When the rotor has revolved to the position shown at *B*, the air

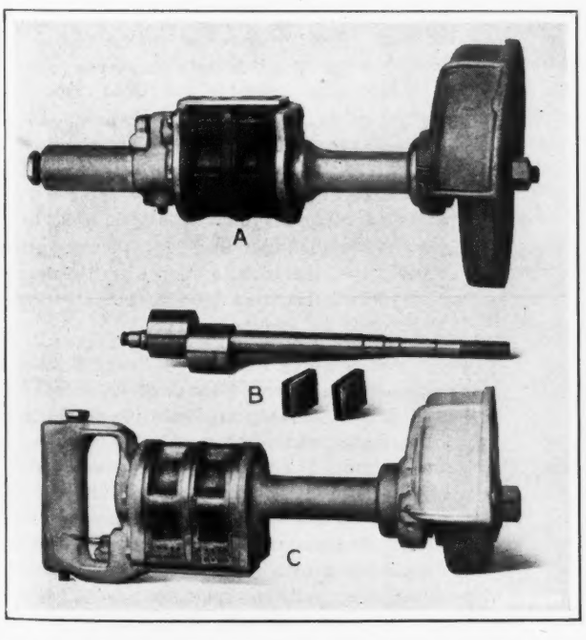


Fig. 1. Two "Roto" Pneumatic Grinders and Rotor Shaft

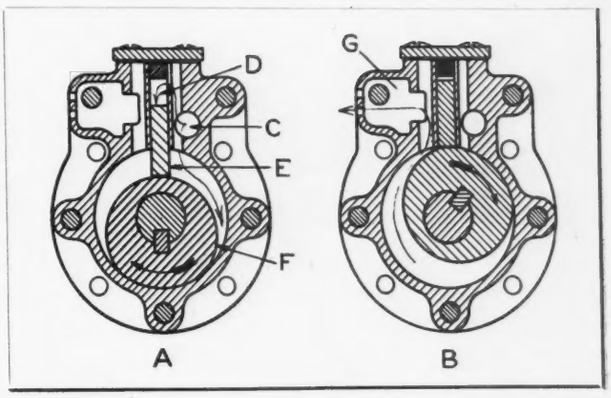


Fig. 2. Section Views which illustrate the Function of the Rotors

enters chamber *G* and is exhausted through the ports. As may be seen at *B*, Fig. 1, two rotors are mounted on the shaft for operation in respective cylinders. The eccentrics of the rotors are directly opposite each other so as to give a balanced effect, and an overlapping power stroke in each cylinder results in a steady flow of power to the grinding wheel without vibration. The two valve blades *E*, Fig. 2, which are also seen at *B*, Fig. 1, are made of a special light fiber so as to reduce the momentum due to reciprocation.

Disregarding friction between the shaft and two ball bearings in which the shaft is mounted, there are but two points of frictional contact; these are the contact points of the two blades on the eccentric surface of the rotors. Since the blades are made of fiber, they absorb such wear as occurs, and wear is thus confined to two easily replaceable parts. In replacing the blades, it is only necessary to remove the cap at the top of the cylinders by means of a screwdriver, insert the new blades, and replace the cap. There is no frictional contact between the surface of the rotors and the cylinder walls, as a clearance of from 0.002 to 0.003 inch is provided. A constant oil film seals this clearance and prevents any leakage of air past the rotor.

An oil reservoir is provided in the air inlet to hold an ample supply of oil for the average day's run. This oil is fed into the cylinders in the form of a mist, which is easily adjusted by means of a needle valve. The shaft and rotors are made of chrome-nickel steel, and the housings and handle of aluminum. Either a straight handle can be furnished, as shown at *A*, Fig. 1, or a spade type of handle, as illustrated at *B*. The grinders operate at pressures varying from 65 to 90 pounds per square inch with an air consumption of from 32 to 40 cubic feet per minute, which remains constant.

These grinders are made in several sizes for different applications: Type D-2 is intended for general grinding, and is equipped with either an 8- by 1-inch or a 6- by 1½-inch wheel; it has a free speed of 4500 revolutions per minute, and weighs 15 pounds. Type D-2-X is manufactured for buffing and polishing operations where high speeds are required, the free speed with an 8- by 3-inch aluminum buffing wheel being 6000 revolutions per minute. This grinder also weighs 15 pounds. Type D-1 is made for light grinding work and for automobile body buffing. It is also suitable for wire-brush cleaning and polishing. The equipment weighs 8¼ pounds, is provided with a 6- by 1-inch wheel, and may be furnished for operation at speeds of from 3500 to 7000 revolutions per minute.

BETTS DOUBLE-HOUSING PLANERS

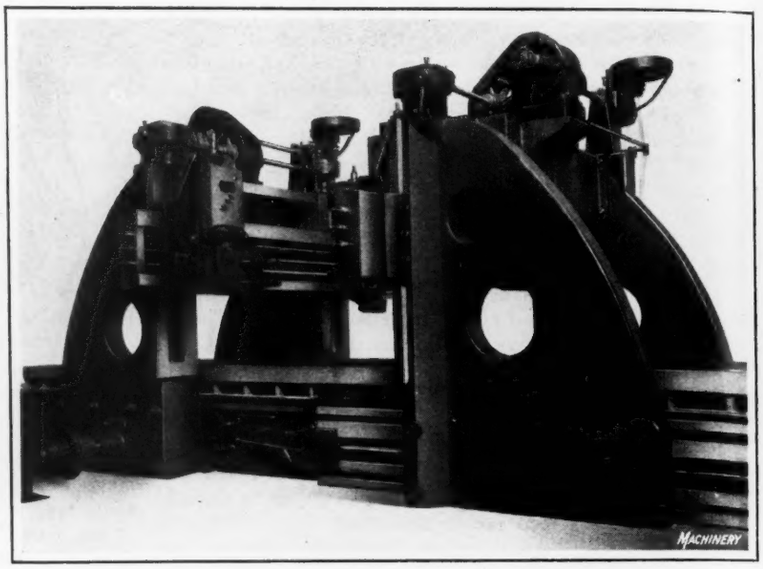
In planing locomotive guides and similar work, it is often desirable to take a cut in both directions of the table movement in order to obtain maximum production. Several heavy-duty planers designed on this principle have recently been built by the Betts Machine Works, Rochester, N. Y., of the Consolidated Machine Tool Corporation of America. One of the features of these machines is that two sets of

housings are used, each carrying a cross-rail on which two heads are mounted. As the two cross-rails face each other, two cutting tools may be constantly at work. One set of housings is bolted to the bed in the usual manner, while the other set is adjustable along the bed to accommodate various lengths of work. The adjustment is accomplished by means of slides, screws, and nuts. A separate motor is used to move this set of housings to the desired position, and there is provision for clamping it to the bed.

Power for the main drive is delivered by a 50-horsepower reversing motor having a speed range of from 250 to 500 revolutions per minute. The entire speed range is used for cutting only, the usual high return speeds being dispensed with. All driving gears and the rack are made of steel and have a wide face and coarse pitch. The four heads are equipped with an electric feed and power rapid traverse, there being one motor for each set of uprights. These motors also furnish the power necessary for raising and lowering the cross-rails. Convenient push-button stations are used for controlling the different motors.

The cross-rails are clamped to the housings at both the inside and outside edges, and are carried back between the housings a sufficient distance to provide ample rigidity when the tools are cutting close to the center of the table. The table is of unusual thickness, of box type construction, and is gibbed to the bed for its full length so as to prevent any tendency to rise during heavy cutting. The bed is made with a wide distance between the table tracks and carries the dead shafts on which the driving gears are mounted.

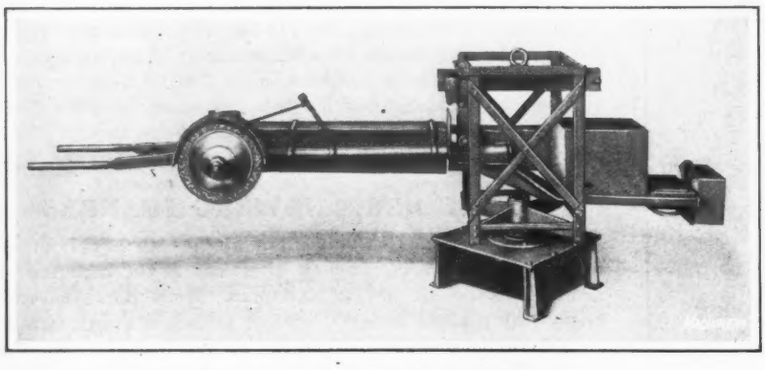
The table tracks, driving gears, and driving-gear bearings have forced lubrication in connection with a filtering system, so that an ample supply of clean oil is insured to these important points. For this system there are two pumps driven by an independent motor mounted on the outside of the machine. One pump forces the oil through the machine, and the other brings it back and forces it through the central filtering unit. In addition to forced lubrication, the table tracks are provided with the usual oil pockets and rollers. The width between the housings of these planers is 57 inches, and the maximum distance between the table and the cross-rails, 31 inches. The length between the table pockets is 20 feet.



Betts Double-housing Planer which takes Cuts on Both Forward and Return Table Movements

FARRELL-CHEEK SWING-FRAME GRINDER

A swing-frame grinder for rough-grinding operations has recently been brought out by the Farrell-Cheek Steel Foundry Co., Sandusky, Ohio, primarily for use in steel foundries and mills. The grinder is portable, and, in addition, it revolves through a complete circle about a base on dustproof roller bearings. The grinding wheel is located outside of the bearing housings and is driven by a ball-bearing equipped motor. The motor, driving belt, and starter are entirely enclosed, starting and stopping of the motor being effected through push-buttons conveniently located for the operator. Alemite lubrication is used throughout.



Farrell-Cheek Portable Swing-frame Grinder

* * *

NEW MACHINERY AND TOOLS NOTES

Swaging Machine: Coulter & McKenzie Machine Co., 771 Water St., Bridgeport, Conn. A rotary swaging machine for shaping square and flat taper points, in which the dies do not revolve but are actuated by rollers carried on a rotating outer sleeve. Almost any shape of bar stock can be swaged, but the swaged section will be either square or flat. The machine is particularly suited to forming file tangs and screwdriver blanks. Two sizes are built, one for handling stock up to 5/16 inch diameter or square, and the other taking stock up to ½ inch.

Internal Grinding Machine: Micro Machine Co., Bettendorf, Iowa. A heavy-duty internal grinding machine particularly adapted for railroad shop use, in which a pantograph type of drive keeps the spindle speed constant. To secure a desirable work speed for holes of different sizes, the orbital travel of the grinding wheel spindle may be varied. Also, in order to facilitate centering the work, the main bearing can be revolved by means of a handwheel. A universal work-holding fixture is mounted on a cross-slide subplate to which work can be attached on either side of parallel bars which can be adjusted individually or as a unit. The standard grinding range includes holes from 2½ to 10 inches in diameter and 19 inches deep, but with the machine equipped with special spindles, holes from 1 to 15 inches in diameter may be ground.

Arc Welding Machine: Wilson Welder & Metals Co., Inc., Wilson Bldg., Hoboken, N. J. A portable arc welding machine of the motor generator type with a range of adjustment from 75 to 250 amperes by small steps, and a self-contained gasoline-engine driven unit of from 75 to 200 amperes capacity. The motor-driven unit is intended for rapid work with electrodes up to ¼ inch in diameter, and the gasoline-engine driven machine for use with electrodes up to 3/16 inch in diameter.

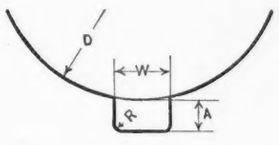
LARGER KEYWAYS IN MILLING CUTTERS

By FRED A. PARSONS

In October MACHINERY, page 102, an editorial appeared entitled "Larger Keyways in Milling Cutters." In this connection, the writer wishes to state that nearly twenty-five years ago the Kearney & Trecker Corporation, Milwaukee, Wis., concluded that the standard cutter and arbor keyways were too small to stand up under the cuts possible with the geared-head milling machine that the company was then introducing, and therefore originated the standard shown in the accompanying table. For some years now several of the leading cutter manufacturers have furnished standard cutters with these larger keyways, sometimes putting in both the larger keyways and the smaller keyways formerly considered standard, so that the cutters could be used on arbors of either standard.

There are already a great many arbors and cutters in existence with these larger standard keyways, and if a standard is adopted, it would seem advisable to conform to the sizes given in the table, which have proved thoroughly satisfactory in practice. For milling cutters as made at the present time, for use with the present-day heat-treated alloy steel arbors on modern geared-head milling machines, the larger standard keyways, as tabulated, ought to be used.

SIZES OF KEYWAYS IN MILLING CUTTERS
(Adopted by the Kearney & Trecker Corporation)



Diam. of Hole in Cutter, D	Width of Keyway, W	Depth of Keyway, A	Radius, R
7/8	0.1300	5/64	3/64
1	0.2550	7/64	3/64
1 1/4	0.3175	9/64	1/16
1 1/2	0.3800	11/64	1/16
1 3/4	0.5050	13/64	1/16
2	0.5050	13/64	1/16

Machinery

SIZES OF KEYSEATS IN MILLING MACHINE ARBORS
(Adopted by the Kearney & Trecker Corporation)

Diameter of Arbor	Width of Keyseat	Depth of Keyseat	Sizes of Key Stock	Diam. of Arbor Collar
7/8	0.1270	1/16	1/8 by 1/8	1.365
1	0.2520	3/32	1/4 by 3/16	1.490
1 1/4	0.3145	1/8	5/16 by 1/4	1.740
1 1/2	0.3770	5/32	3/8 by 5/16	2.115
1 3/4	0.5020	3/16	1/2 by 3/8	2.365
2	0.5020	3/16	1/2 by 3/8	2.677

Lengths of arbor collars, 1/2, 3/4, 1 1/2, 2 and 3 inches

Machinery

* * *

Thousands of obsolete machine tools are in wasteful use, a drag on civilization and on the user's pocket-book as well. Every obsolete machine tool continued in wasteful use challenges the selling ability of the builder of better machines. The machine tool industry must build up an appreciation of the fundamental waste in business caused by obsolete equipment. As this idea is built up, it will persistently work to the elimination of obsolete machines from users' shops. Every obsolete machine in use where a better one should be used, violates the main law for that tool's existence. That law is: Capital invested in machinery must earn the greatest profit possible.—*Ernest F. DuBrul*

C. WOOD WALTER

The twentieth of last month marked the twenty-fifth milestone of C. Wood Walter's busy and useful association with the Cincinnati Milling Machine Co., of which he is vice-president and secretary, an event which was not allowed to pass unnoticed by his business associates and friends in the machinery industry.

An inquiry by wire for some details with which to construct a short biographical sketch brought the reply from Mr. Walter that he "had not had any particular biography — just twenty-five years of hard work and happy association with a company that I personally am very proud of. Quite unexpectedly to me my associates seemed to feel that twenty-five years of identification with our company, and in a small way with the industry generally, was worth a little celebration. One thing is certain, and that is that I have greatly appreciated the kind expressions which I have received from my friends throughout the industry. This of itself is reward enough (if reward is needed) for twenty-five years of effort in our particular field of industrial development."

The writer remembers Mr. Walter some twenty-five years ago as a very live newspaper man, and if Mr. Geier had not had the good fortune to divert his unbounded energy into a field where real money was made, he might have been struggling along as a publisher or editor during the past twenty-five years, instead of having been a factor in the development of a great industry.

* * *

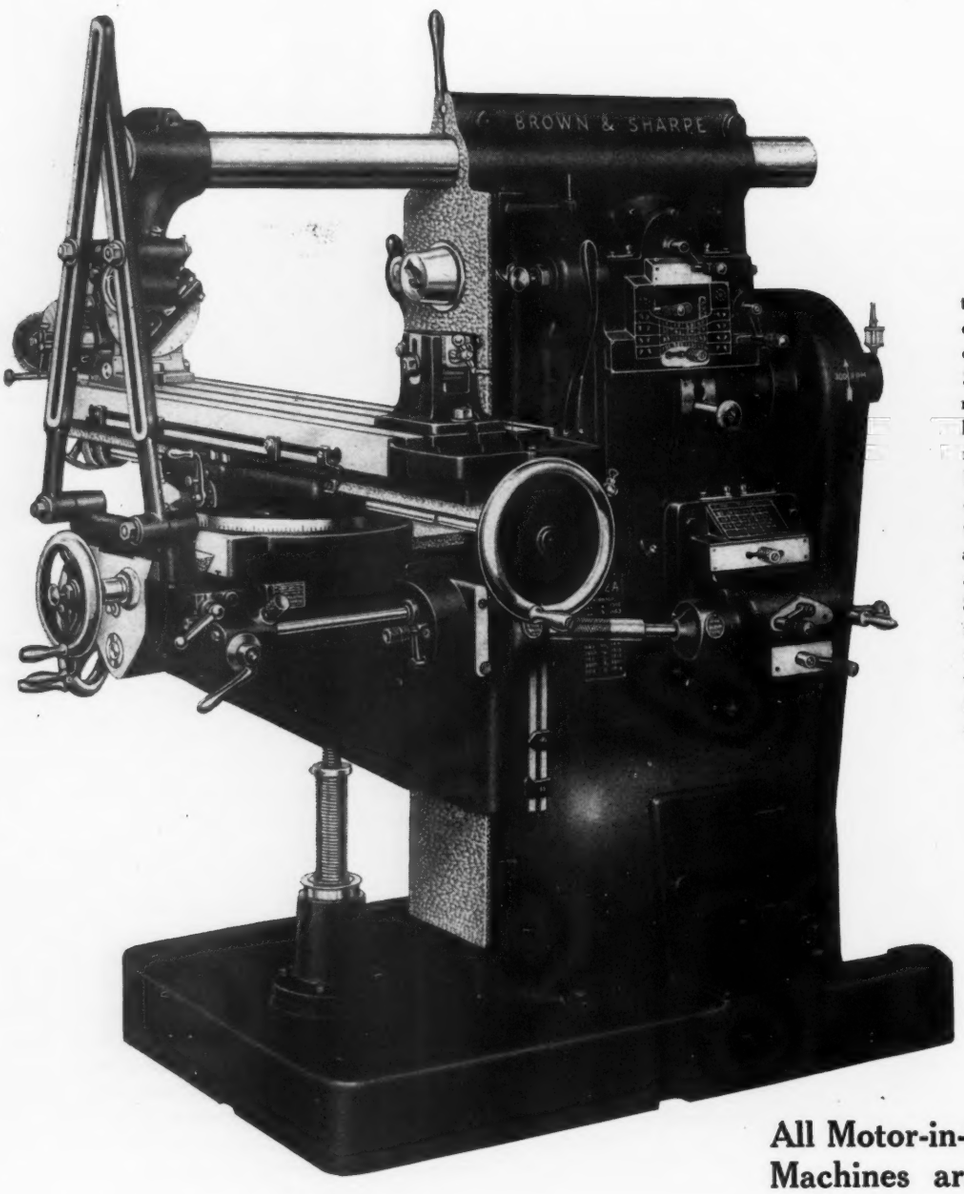
ENGINEERING RESEARCH GRADUATE ASSISTANTSHIPS

To assist in the conduct of engineering research, the University of Illinois maintains fourteen Research Graduate Assistantships in the Engineering Experiment Station of the university. These assistantships, for each of which there is an annual stipend of $600 and freedom from all fees, except matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools, who are prepared to undertake graduate study in engineering, physics, and applied chemistry. The appointment to the post of Research Graduate Assistant is made and must be accepted for two consecutive collegiate years of ten months each. Additional information may be obtained by addressing the Director of the Engineering Experiment Station, University of Illinois, Urbana, Ill. Applications for the Graduate Assistantships must be received not later than April 1.

* * *

As an example of the savings possible by the use of modern lift-truck equipment, the following results obtained in one factory may be of interest. The work formerly done by eight men in storing material 5 feet high is now being performed by three men storing the material 8 feet high. The equipment, which eliminates the labor of five men and incidentally saves over one-third of the floor space, cost $4300 to install. As the aggregate weekly wages of the five replaced men was $120, the saving in wages alone paid for the equipment in about thirty-six weeks.

FIVE YEARS AGO—We Made Our First Motor-in-the-Base Milling Machine



Five years ago

to meet the special requirements of certain customers, Brown & Sharpe developed this new type of Milling Machine which has the motor enclosed in the base. These first machines were so satisfactory that they created a demand for this type, and now Brown & Sharpe have in their regular line three sizes, each of standard Universal and Plain Motor-in-the-Base Milling Machines.

All Motor-in-the-Base Milling Machines are adaptable to either belt or motor drive

BROWN &

TODAY–This Type is included in Our Regular Line in Nos. 1A, 2A and 3A Universal and 1B, 2B and 3B Plain Milling Machines

Special Features—

Oil-tight Motor Compartment

Ventilators on Three Sides of Motor Compartment

Large Cutter Lubricant Reservoir in Base Under Knee

Silent Chain Entirely Enclosed

Motor Very Accessible

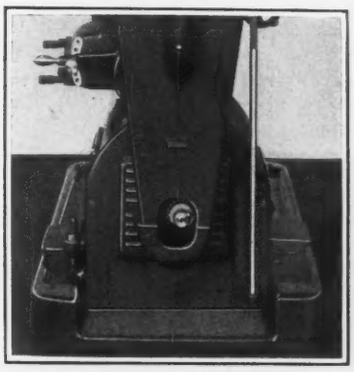
Adapted to Either Belt or Motor Drive

These new features, combined with the many fine qualities for which Brown & Sharpe Milling Machines have long been noted, made the Motor-in-the-base-Type the choice of one of the largest automotive shops and one of the big electrical plants where several machines are doing fine work.

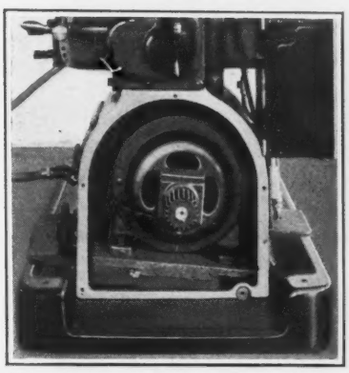
Send for full details on Motor-in-the-base-Type Milling Machines.

Brown & Sharpe Mfg. Co.
Providence, R.I., U.S.A.

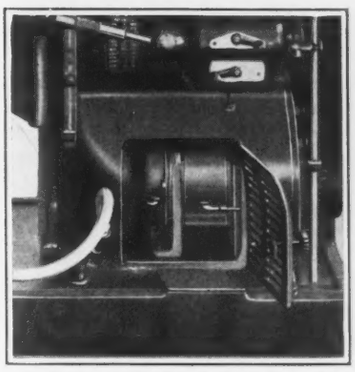
B&SHARPE



Exceptional ventilation for the motor is provided by three sets of ventilators.

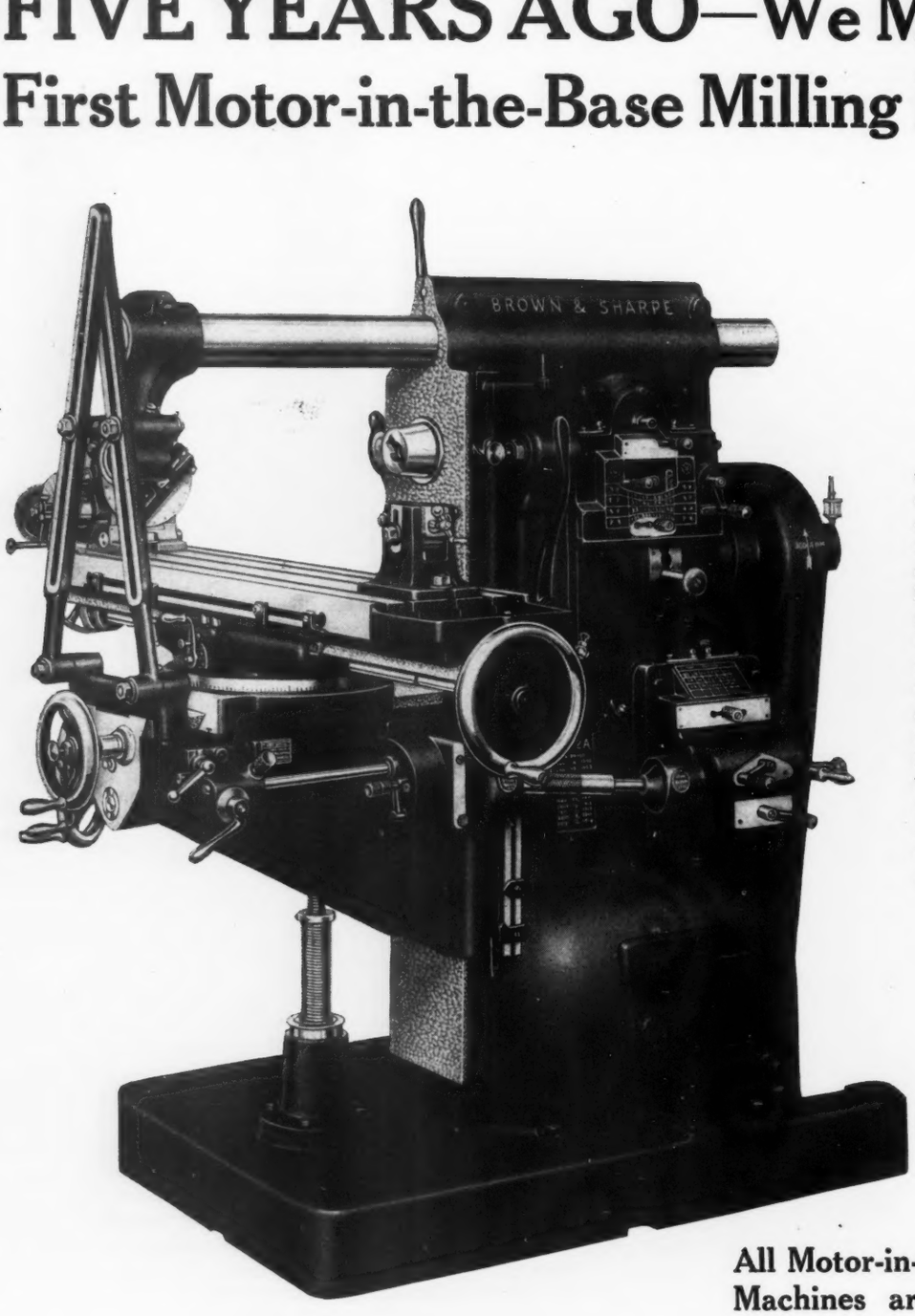


Notice how securely the motor is held in place and how provision is made for adjusting the driving chain from the outside.



The Motor is ventilated from both sides and the rear. Note the accessibility of the motor for oiling and wiring.

FIVE YEARS AGO—We Made Our First Motor-in-the-Base Milling Machine



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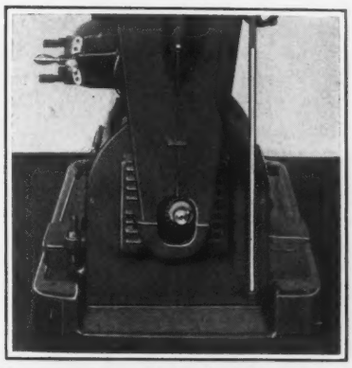
Brown & Sharpe Mfg. Co.
Providence, R.I., U.S.A.

SHARPE



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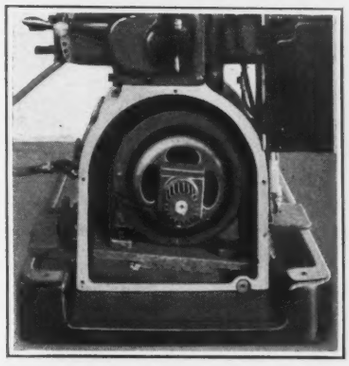

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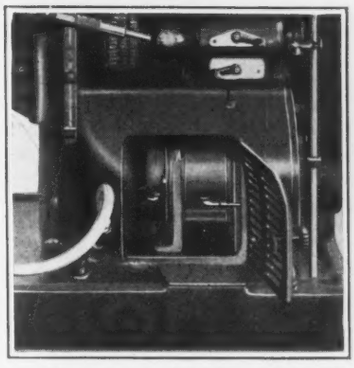


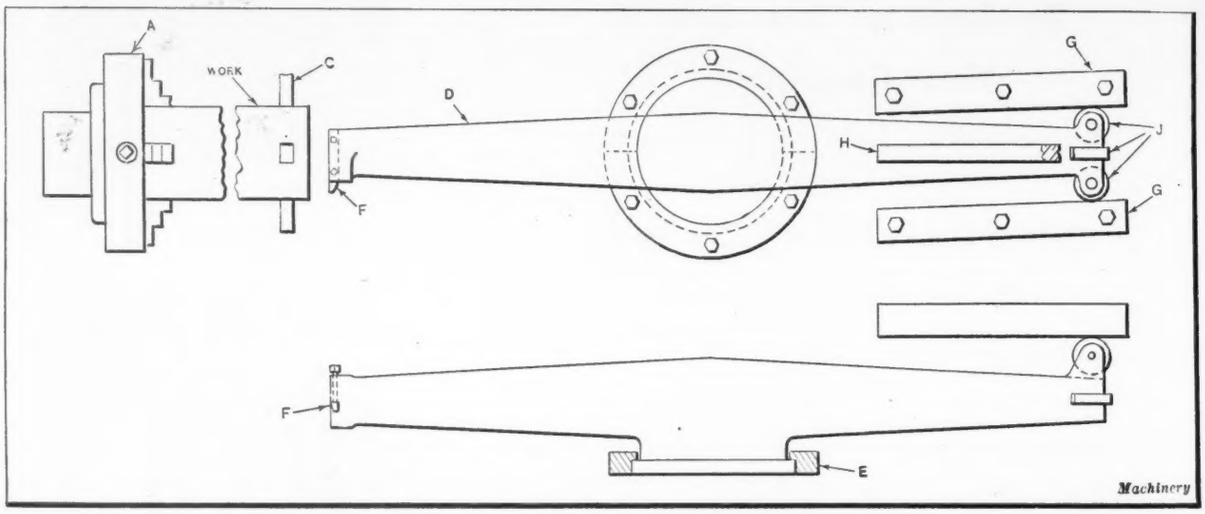
The Motor is ventilated from both sides and the rear. Note the accessibility of the motor for oiling and wiring.

TAPER AND FORM-BORING ATTACHMENT

By DONALD BAKER

The attachment described in this article was designed for use in taper-boring or form-boring the holes in steel cylinders, 10 feet long, with an inside diameter of about 18 inches. The attachment is used for very heavy roughing cuts as well as light accurate finishing cuts. One end of the work is held in the chuck *A*, as shown in the illustration, while the other end is supported by the steadyrest *C*. A special boring-bar *D* is made either from a steel or a gray iron casting which is cored out to reduce its weight. The casting must, however, retain sufficient rigidity to prevent bending when heavy roughing cuts are being taken.

The boring-bar is mounted on a special lathe carriage in such a manner that it can be swiveled or pivoted at the middle point. The swivel bearing ring *E* is carefully fitted and secured to the special lathe carriage by cap-screws. Two set-screws hold the boring tool *F* in place. The two guide bars *G* may either be fixed or made adjustable to any angle as determined by the taper of the hole that is to be bored out. Formed guide bars are used when the holes in the cylinders are bored out to irregular or curved shapes.



Lathe Attachment for Form- and Taper-boring Operations

A frame that is bolted and doweled to the bed of the lathe serves as a support for the guide bars.

In addition to the bars *G* which determine the form of the bored hole, a third bar *H* is mounted on the framework that supports the other bars. Bar *H* is located parallel with the lathe bed. On the outer end of bar *D* are mounted three hardened steel rollers *J* which rest against the guide bars. The upward strain imposed on the rear end of the boring-bar is taken by bar *H* which is in contact with the roll *J* mounted on the upper side of the bar. Very accurate finishing cuts are taken with the attachment described, and it has given excellent service for several years. While the attachment was designed primarily for large work, it can, of course, be used to advantage on small odd jobs such as are frequently encountered in every machine shop.

* * *

RESULTS OF STANDARDIZATION

In a paper presented before the annual meeting of the American Engineering Standards Committee, F. L. Rhodes stated that standardization work brings about the following advantages: (1) Standardization makes the best available for all. (2) Standardization reduces cost because, when all makers use the same things, they can be manufactured in the largest quantities; and uniformity in output contributes to economies in production. (3) Standardization reduces the cost of carrying stocks of materials and the cost of maintenance and repairs, because fewer parts have to be carried. (4) Standardization reduces the cost of instruction of new employes, because there are fewer things to get acquainted with. (5) Standardization reduces accounting costs, because there are fewer types and sizes of materials to keep track of. (6) Standardization minimizes complicated engineering and operating problems that might result from intercommunication between widely divergent systems and apparatus. (7) Standardization renders available enormous supplies of materials and labor in emergencies. (8) Standardization greatly facilitates development work. If everything varied from everything else, there would be no definite point of departure from which to start to improve.

* * *

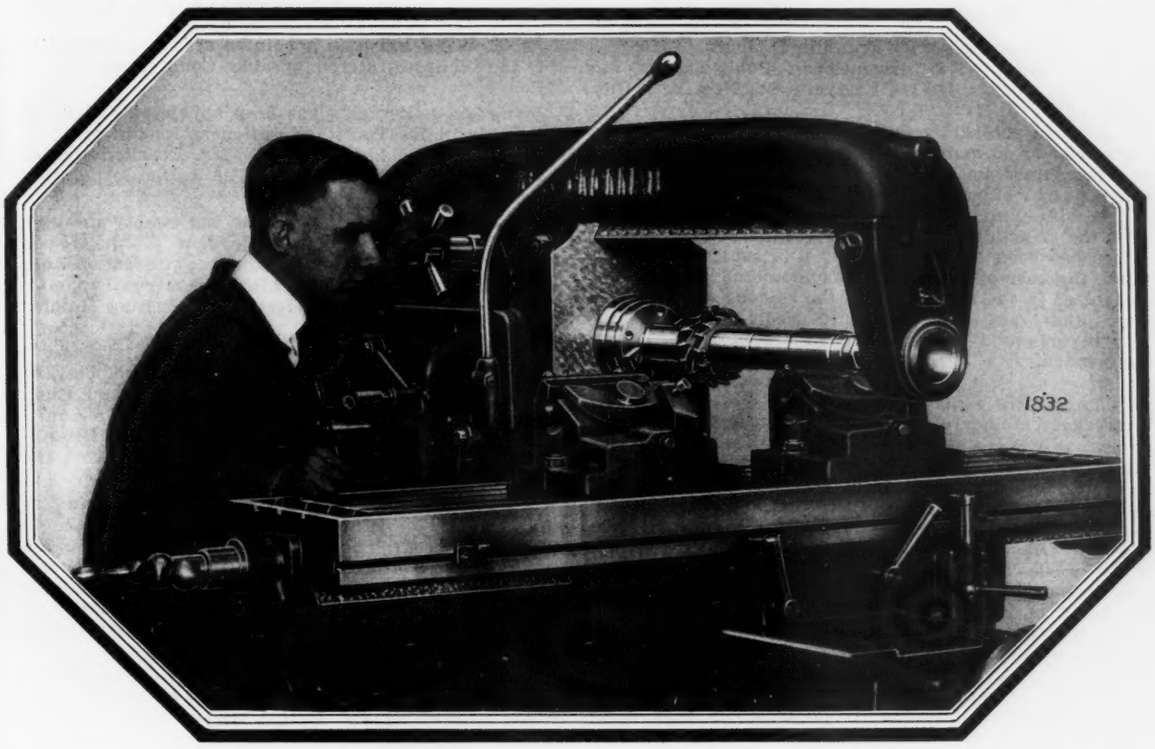
MACHINE TOOL DEALERS' ORGANIZATION

An organization of machine tool dealers known as the Associated Machine Tool Dealers was recently formed in Cincinnati. It is the aim of the new organization to work in cooperation with machine tool builders for the betterment of the industry. The association is composed of executives of member companies, of which about forty are eligible. The officers are: President, George E. Merryweather, Motch & Merryweather Machinery Co., Cleveland, Ohio; vice-president, Marshall Prentiss, Henry Prentiss & Co., Inc., New York City; secretary, Tyler Carlisle, Strong, Carlisle & Hammond Co., Cleveland, Ohio; and treasurer, George H. Cherrington, Brown & Zortman Machinery Co., Pittsburg, Pa. The directors, in addition to the officers, are Charles E. Busch, Charles A. Strelinger & Co., Detroit, Mich.; L. H. Swind, Swind Machinery Co., Philadelphia, Pa.; J. R. Vandyck, Vandyck Churchill Co., New York City; J. W. Wright, Colcord-Wright Machinery & Supply Co., St. Louis, Mo.; and W. J. Radcliffe, E. A. Kinsey Co., Cincinnati, Ohio.

* * *

MANAGEMENT ASSOCIATION CONVENTION

The annual convention of the American Management Association was held at the Hotel Astor, New York City, January 28 to 30. A comprehensive program was presented, papers being read on a number of subjects of general interest in the management field. Among the subjects dealt with were the measuring and grading of the supervisory forces, comparison between a business and a modern army organization, health supervision, employe magazines, the participation of public schools in apprentice training, the placing and introducing of employes, limitations in the use of psychological tests, employe lunch-rooms, personnel records, classroom training of employes, and payroll administration. Copies of the papers may be obtained from the American Management Association, 20 Vesey St., New York City.



One Hand Shifts the Overarm

Here is setting up convenience—an easy turn of the wrist, adjusts the Cincinnati Rectangular Overarm (patented). No stretching or straining. Just a turn of the pilot wheel and the overarm slides on its scraped bearings.

The arbor support with its adjustable bronze bushing, slides snugly over the arbor bearings, the overarm is quickly locked by two conveniently located bolts and the machine is ready for the cut.

Particularly in the tool-room, this Cincinnati convenience is a real time and effort saver. Think what it would mean on *your* work. Send for the special booklet fully describing other equally valuable features on our No. 2 and No. 3 High Power Rectangular Overarm Millers.

"KNOW YOUR COSTS"

ENGINEERING SERVICE

From your blueprint or sample part accompanied by brief data, our special engineering service department will give you a complete estimate including time studies, sketches of fixtures, descriptions of operations and quotations. Our recommendations are based upon our experience with leading manufacturers on this particular engineering service work for the past eleven years.

Send for an estimate blank—fill it out—return it—we'll do the rest.

THE CINCINNATI MILLING MACHINE COMPANY
CINCINNATI, OHIO

CINCINNATI MILLERS

NEW BOOK ON GEAR CUTTING

GEAR CUTTING PROCESSES. By Franklin D. Jones. 342 pages, 6 by 9 inches; 173 illustrations. Published by THE INDUSTRIAL PRESS, 140-148 Lafayette St., New York City. Price, $3.

The object in publishing this treatise on gear-cutting practice has been to do more than merely explain how different types of machines are adjusted and used for the cutting of different classes of gearing. The aim has been to aid the reader in obtaining a clear understanding of the relation between the principles of gearing and gear-cutting processes. An effort has been made to present this subject in such a way that the user of the book will understand not only the methods used in cutting gears, but the reasons why different processes and types of machines are used to meet commercial requirements in the varied branches of the machine-building industry.

In view of the fact that gear-cutting processes are based directly on certain fundamental principles of gear design, the first chapter explains briefly the important underlying principles, as well as the meaning of various terms which are used frequently in all treatises on gearing. As the degree of accuracy essential for a given class of gearing ordinarily has a decided bearing upon the most practicable and economical method of forming the gear teeth, the relation between various types of gear-cutting machines and the classes of work for which they are adapted, has also been carefully considered.

The cutting of all ordinary types of gearing is dealt with, including spur gears, straight-tooth bevel gears, spiral bevel gears, helical and herringbone gears, internal gears, racks, worm-gears, and worms. There are numerous examples from practice, with commercial rates of production, for gears cut by different processes. Recent developments in both gear-cutting and gear-tooth grinding are included, and specific information is given covering operating principles and the methods of setting up or adjusting machines of different types. The use of standard milling machines for gear-cutting is explained, as such machines are often employed where types designed primarily for gear-cutting are not available.

The book is divided into sixteen chapters headed as follows: General Principles of Gearing and Classification of Cutting Processes; Use of Standard Milling Machines for Gear-cutting; Cutting Spur Gears on Automatic Gear-cutting Machines; Cutting Spur Gears on Gear Shapers and Gear Planers; Hobbing Process as Applied to Spur Gears; Cutting Internal Spur Gears; Formed-cutter and Generating Methods of Cutting Bevel Gears; Cutting Large Bevel Gears on Planers of Templet Type; Machines of Generating Type for Cutting Spiral Bevel Gears; Special Machines for Roughing Bevel Gears and Pinions; Cutting Helical Gears on Hobbing Machines and Gear Shapers; Cutting Double-helical Gears on Hobbing Machines and Planers; Rack-cutting; Cutting Worm-gears and Worm Threads; Small Gears for Instrument Work; Finishing Gear Teeth by Grinding.

* * *

THE LEIPZIG FAIR

So many references are made to exhibitions at the Leipzig Fair that American readers may be interested in knowing exactly what this fair is and what purposes it serves. At Leipzig, Germany, two fairs are held each year, these fairs being sales exhibits of commercial products. Several fairs of this type are held annually in Europe, but of these the Leipzig Fair is now the largest. The first fair opens on the first Sunday in March, and the second on the last Sunday in August. Each fair lasts about ten days and is divided into two sections—a general sample exhibit held in buildings specially constructed for this purpose at a central point in Leipzig, and an engineering and building trades exhibit held at the exhibition grounds.

At these fairs, the average number of exhibitors is about 15,000, and the number of products and samples exhibited is so large that the exhibition buildings cover an area of about 65 acres. The average number of visitors at each of these fairs is about 150,000; of these, 30,000 are usually from countries outside of Germany. The organization and management of the exhibit is in the hands of the Messamt für die Mustermessen, Markt 4, Leipzig, Germany.

The machine tool exhibition is held only in connection with the spring fair, which this year will be from March 1 to 11. At this exhibit the Association of German Machine Tool Builders will exhibit, and anyone interested in the exact status of the German machine tool industry will be able to obtain an accurate idea at this exhibit, which is a most complete collection of German machine tools. The exhibit of German metal-working machines this year is expected to be the most extensive ever held.

PERSONALS

A. C. WARN has been appointed assistant general manager of the Eclipse Interchangeable Counterbore Co., Detroit, Mich.

WILLIAM J. EBERLIEN has been appointed district manager of the Williams Tool Corporation at its Chicago branch office, 549 W. Washington Blvd. Mr. Eberlien was formerly associated with the Greenfield Tap & Die Corporation at its factory in Greenfield, Mass.

WILLIAM H. LUCAS, JR., for the last twenty-one years chief engineer and factory superintendent of the Espen-Lucas Machine Works, Philadelphia, Pa., builder of automobile production and special machinery, has been appointed factory and production manager for the Delling Motors Co., at West Collingswood, N. J.

GEORGE I. DANLY has been appointed manager of the eastern sales division of the Danly Machine Specialties, with headquarters at 35 Wilbur Ave., Long Island City, N. Y. Mr. Danly will be assisted by Charles F. Schonmann, formerly with the American Can Co. and the E. W. Bliss Co. All eastern sales are now being filled directly from the Long Island City warehouse.

J. E. STOVER, who has been connected in a sales engineering capacity for a number of years with the Van Dorn & Dutton Co., Cleveland, Ohio, specialists in gears and gear cutting, has been promoted to the position of assistant sales manager. Mr. Stover became associated with the company shortly after his graduation from Penn State University and has been connected with both the manufacturing and the selling end of the business.

FRANK A. SCOTT, past president of the Cleveland Engineering Society, has been appointed Chief of the Cleveland Ordnance District of the United States Army. He succeeds Colonel Bascom Little in this position. Mr. Scott's duties will involve the coordination of industries in Cleveland and Ohio for the production of munitions for national defense in time of emergency. During the first eight months of the war, Mr. Scott was chairman of the General Munitions Board and the War Industries Board, at Washington, and participated in organizing the entire productive facilities of the country for war. Mr. Scott was awarded the Distinguished Service Medal for these services. The new office carries with it the rank of colonel, as Mr. Scott is a colonel in the Ordnance Officers' Reserve Corps.

COLONEL EUGENE C. PECK, who has been associated with the Cleveland Twist Drill Co., Cleveland, Ohio, for nearly twenty-five years, has retired from active management. He will continue as a stockholder and a member of the board of directors. Colonel Peck entered the employ of the company on June 1, 1900, as inventor, designer, and draftsman. A few years later he was made superintendent, and since that time has held the position of works manager, having entire charge of the manufacturing department. Colonel Peck has long been a constructive force in the tool industry. Serving as a member of the American Engineering Standards Committee, as chairman of the Standardization Committee of the American Society of Mechanical Engineers, and as vice-chairman of the National Screw Thread Commission, he has been largely responsible for many much-needed reforms in standards of practice. During the war, he served as chief of the gage section of the engineering division of the army, with the rank of lieutenant-colonel, and was in charge of the work of design and procurement of gages for all ordnance material. Upon his retirement he was presented with a watch by F. F. Prentiss, vice-president, on behalf of the board of directors.

OBITUARY

GLENN GRENVILLE HOWE, for many years senior vice-president of the Link-Belt Co., Chicago, Ill., died at his home in Muskegon, Mich., on Christmas day, after a year's illness. Mr. Howe first became connected with the Link-Belt organization in 1877, at the age of sixteen, as an office boy. Following his mechanical bent, he drifted into the manufacturing department and later became superintendent of the Ewart Mfg. Co. In 1906, when the three related interests, the Ewart Mfg. Co., the Link-Belt Machinery Co., and the Link-Belt Engineering Co., were merged into one as the Link-Belt Co. Mr. Howe became vice-president in charge of the company's Indianapolis operations. He continued as senior vice-president until failing health led to his retirement from active business. Later, with returning health, he organized the Howe Chain Co. at Muskegon, holding the position of president of that concern, which was sold to the Link-Belt Co. in January, 1924.

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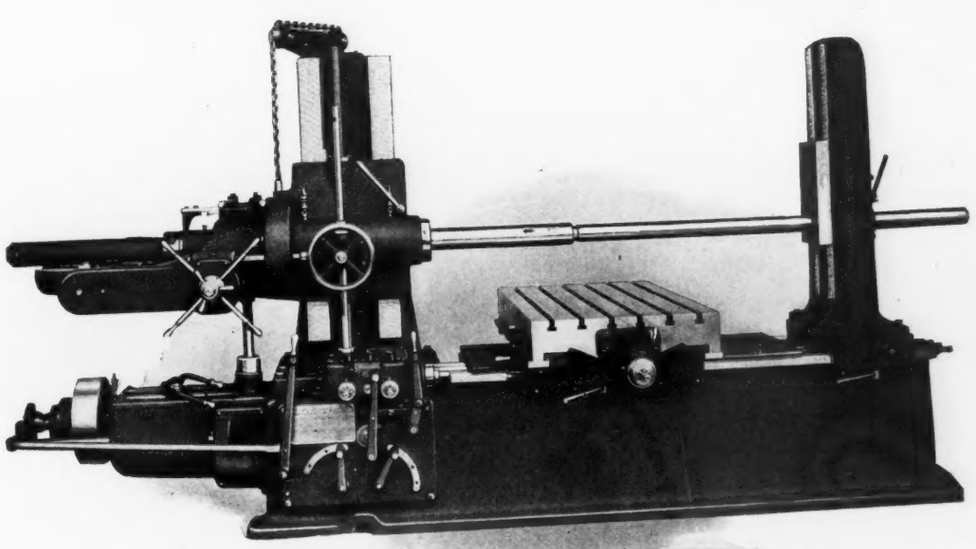
Business has taken an upward start, therefore
Get a LUCAS

"PRECISION"

Horizontal Boring, Drilling and MILLING MACHINE



while the getting is good.

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LUCAS POWER
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LUCAS MACHINE TOOL CO. NOW AND ALWAYS OF CLEVELAND, OHIO, U.S.A.

FOREIGN AGENTS: Alfred Herbert, Ltd., Coventry. Societe Anonyme Belge, Alfred Herbert, Brussels. Allied Machinery Co., Turin, Barcelona, Zurich. V. Lowener, Copenhagen, Christiania, Stockholm. R. S. Stokvis & Zonen, Paris and Rotterdam. Andrews & George Co., Tokyo.

TRADE NOTES

HUSKY WRENCH CO., 928 Sixteenth Ave., Milwaukee, Wis., has opened an export office at 280 Broadway, New York City. Benjamin Hacker will be export manager in charge of the foreign distribution of Husky interchangeable-socket wrenches.

FOOTE BROS. GEAR & MACHINE CO., 232-242 N. Curtis St., Chicago, Ill., has recently completed arrangements with the F. Somers Peterson Co. of San Francisco, Cal., for the distribution of IXL gear products and speed reducers in northern California; and with the Thomas Machinery Co. of Los Angeles for the southern section.

CHICAGO PNEUMATIC TOOL CO., 6 E. 44th St., New York City, has appointed the Smith & Woodbury Co., 55 Second St., Portland, Oregon, distributor for Oregon and southwest Washington of the products of the company, including a complete line of pneumatic and electric tools, rock drills, air compressors, and semi-Diesel oil engines.

DANLY MACHINE SPECIALTIES, INC., 4907 Lincoln Ave., Chicago, Ill., has opened two new warehouses and offices at 35 Wilbur Ave., Long Island City, N. Y., and 1537 Temple Ave., Detroit, Mich. Complete stocks of assembled die sets are carried at both these plants, as well as "knocked down" die sets. The capacity of the Chicago plant was recently tripled to meet the increasing demand for the company's die sets.

HERMAN A. HOLZ, testing engineer, 17 Madison Ave., New York City, has been appointed sole agent for the sale of the various types and models of Brinell hardness testing machines made by Aktiebolaget Alpha, Sundbyberg, Sweden. Mr Holz will carry an ample stock of Brinell machines in New York City, thus being able to make prompt deliveries, and he will also give any desired technical information on hardness testing.

HANSON TAP & GAUGE CO., has been merged with the HANSON-WHITNEY MACHINE CO., Hartford, Conn. The combined interests will now be operated under the name of the Hanson-Whitney Machine Co. The Whitney Mfg. Co. and the Hanson-Whitney Machine Co. will jointly maintain offices in a number of leading industrial centers. Two offices have already been opened, one in the General Motors Building, Detroit, Mich., and the other in Machinery Hall, Chicago, Ill.

RELIANCE ELECTRIC & ENGINEERING CO., 1056 Ivanhoe Rd., Cleveland, Ohio, has awarded a contract to the Austin Co., of Cleveland, for the addition of a new unit to its plant at Ivanhoe Road, near Five Points. The new extension will include a one-story section with sawtooth roof, and a two-story section, both of mill type construction. The one-story section is to be used for increasing the capacity of the machine shop and assembly departments, as well as for finished stock storage. The two-story section will be devoted to the armature and coil-winding department.

UNION DRAWN STEEL CO., Beaver Falls, Pa., has purchased the plant of the Frasse Steel Works, Inc., at Hartford, Conn. The output of the Hartford plant will be used to serve the New England and eastern trade. Peter A. Frasse & Co., Inc., Buffalo, N. Y., will act as distributors of the Union Drawn Steel Co.'s products from their warehouses in New York City, Buffalo, and Philadelphia. The tool steel and hot-rolled alloy steel business of Peter A. Frasse & Co. has not been sold, and the company will continue to anneal and certify tool steel and heat-treat alloy steel at Hartford.

QUEEN CITY STEEL TREATING CO., and METALLURGICAL SERVICE CO., both of Cincinnati, Ohio, combined their businesses on the first of the year, and are now operating under the name of Queen City Steel Treating Co. E. P. Stenger, president and manager of the latter company, is the active head of the corporation. In addition to operating a commercial heat-treating plant, the company will sell heat-treating equipment and supplies, acting as Cincinnati district representative for the American Gas Furnace Co., the Case Hardening Service Co., Charles Engelhard, Inc., the General Alloys Co., and other manufacturers in this field.

U. S. TOOL CO., INC., 117 Mechanic St., Newark, N. J., has acquired the Ampere plant of the General Electric Co., which consists of three new buildings of modern, fireproof construction. The U. S. Tool Co. has formerly operated plants at several places in Newark, but these are now consolidated in its new quarters. The new plant will have 83,000 square feet of floor space, the main part of the plant consisting of two buildings, 300 by 100 feet, one of which is two stories and the other three stories in height. In addition, there is a two-story building, 100 by 100 feet. The principal business of the company is toolmaking, particular attention being given to the manufacture of blanking, drawing, and forming dies, jigs, fixtures, and gages, as well as the design and construction of automatic machinery.

KENT MACHINE CO., Kent, Ohio, has purchased from the National Acme Co. of Cleveland, Ohio, all the drawings, patterns, and tools for manufacturing, and also all the rights to manufacture under patents, the complete line of "Namco" auxiliary machinery, which has been manufactured by the latter company for the last few years. This line of auxiliary machinery was developed by the National Acme Co. for secondary operations in its own screw products plant and the demand for these machines on the part of automatic screw machine users caused the company to place them on the market. Several varieties of machines are included, among which are bar pointing machines, automatic stud threaders, small tool grinders, single-spindle drillers, six-spindle semi-automatic drillers, semi-automatic screw slotters, and two-spindle bolt threaders.

MELDRUM-GABRIELSON CORPORATION, Syracuse, N. Y., manufacturer of Gabrielson milling machines, Syracuse adjustable limit snap gages, special machinery and tools, and the M-G production unit, has made arrangements with the following machine tool dealers to handle the sale of the M-G production unit throughout the United States and Canada: Russell, Holbrook & Henderson, Inc., New York City; Crane-Schiefer-Owens, Inc., Buffalo, Rochester, and Syracuse, N. Y.; Kemp Machinery Co., Baltimore, Md.; Stoer Machinery Co., Philadelphia, Pa.; P. H. McArdle Equipment Co., New Orleans, La.; J. S. Miller Machinery Co., Pittsburg, Pa.; D. C. Slusser Sales Co., Detroit, Mich.; Neff Kohlbusch & Bissell, Inc., Chicago, Ill.; Northern Machinery Co., Minneapolis, Minn.; and Arthur Jackson, Toronto, Ontario, Canada.

MANNING, MAXWELL & MOORE, INC., 140 E. 42nd St., New York City, announces the following changes in the personnel of the sales organization of the machinery department: Joseph Wainwright, formerly district sales manager at Philadelphia, has been appointed eastern sales manager, with headquarters at New York; D. M. McDowell, has been transferred from the New York office to the Philadelphia office of which he will be acting district sales manager; W. A. Deems, formerly master mechanic with the Baltimore & Ohio Railroad, has been appointed sales engineer to cover the eastern and southeastern territories; J. Fontes has been placed in charge of a sales office recently opened at Los Angeles, Cal.; Thomas A. Rees, formerly with the Motch & Merryweather Co. and the Treadwell Engineering Co., has been engaged as salesman at the Pittsburg office; James W. Barr, formerly with the American Tool Works and the Van Dyck-Churchill Co., and Herbert S. Lester, formerly with the Hendey Machine Co., have been engaged as salesmen at the New York office; C. O. Watson, formerly of Syracuse, has joined the sales force at the Buffalo office; Henry I. Knickerbocker has been appointed general office manager of the machinery department at the New York office.

* * *

ARBITRATION OF COMMERCIAL DISPUTES

The Arbitration Society of America, 115 Broadway, New York City, is doing a constructive work in trying to bring about conditions under which it will be possible to settle quickly commercial disputes by arbitration, instead of by the long and costly methods required when cases of that kind are handled in the regular courts. Uniform arbitration laws have already been enacted in the states of New York and New Jersey, and the Arbitration Society is directing its efforts toward having similar laws passed by the legislatures of thirty-seven states that hold legislative sessions this winter. Intensive work in this direction is under way in Pennsylvania, Massachusetts, Ohio, Indiana, Wisconsin, Minnesota, Missouri, Oregon, and Florida, in which states Chambers of Commerce and trade bodies are cooperating vigorously with the society. Properly organized arbitration courts with power to act under the proposed statutes would save American business millions of dollars annually, and eliminate much of the waste of time and effort now involved in commercial disputes settled in the regular courts, with all the delay and technicalities incident to regular court procedure.

* * *

SOCIETY OF AUTOMOTIVE ENGINEERS' MEETING

The annual meeting of the Society of Automotive Engineers was held in the General Motors Building, Detroit, Mich., January 19 to 22. The meeting included sessions on standardization, research, aviation, passenger car body design, steering and wheel-shimmy problems, balloon tires, air cleaner investigations, lubrication, and vapor-cooling systems. Copies of the papers read may be obtained by application to the Society of Automotive Engineers, 29 W. 39th St., New York City.

Note this Advantage

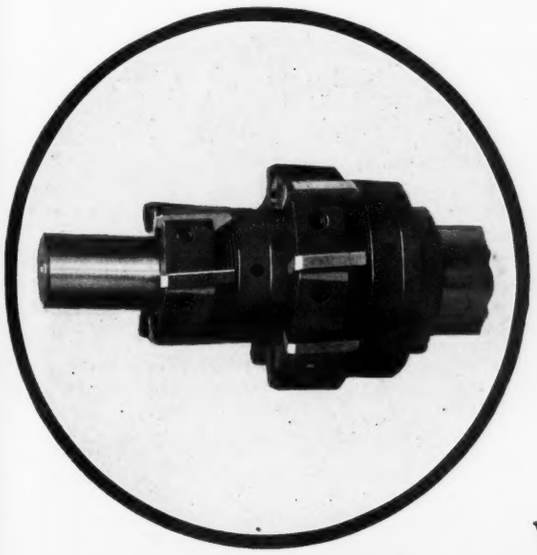
A distinctive feature of this Wetmore Shell Reamer is the ⅛" projection of the blades over the end of the reamer body for chip clearance. This allows the chips to fall off ahead of the reamer body and prevents chips from clogging up along cutting edge of blades.

Another WETMORE REAMER that Cuts Production Costs

Above is shown the *Wetmore Expanding Shell Reamer*, one of the most popular of the Wetmore line. It is turning out job after job that other reamers have fallen down on. More than one user has told us that this Wetmore Shell Reamer has done work which they thought would stump any reamer.

That's why we say: *The Wetmore Expanding Shell Reamer* is guaranteed, absolutely, to lower your production costs. It does quicker work—the reamer stands up longer—blade replacement costs are cut.

This Wetmore Shell Reamer is adaptable for either line or pilot reaming. Fits all standard bars and shell reamer arbors. Body, lock nut and cone nut are finest heat-treated alloy steel. Has .087" expansion. Made in these sizes: 1¼" to 3", 6 blades; 3 1/16" to 5", 8 blades; 5 1/16" to 6", 10 blades. Larger sizes made on order. Made also with straight hole, if desired. Left-hand blades are staggered to eliminate chattering.



At the left is shown how Wetmore Shell Reamers can be adapted for pilot reaming in combination or single. Sizes above 2½" readily adaptable for line reaming.

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Write for Wetmore Catalog, showing full line of standard, heavy duty, shell, small machine and cylinder reamers. Also arbors and replacement blades. Sent *free, postpaid*—no obligation to you.

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WETMORE EXPANDING REAMERS

"THE BETTER REAMER"

COMING EVENTS

MAY 5-7—Joint convention of the Southern Supply and Machinery Dealers' Association and the American Supply and Machinery Manufacturers' Association in Atlanta, Ga.; headquarters, Atlanta-Biltmore Hotel. Secretary-Treasurer, F. D. Mitchell, 1819 Broadway, New York City.

MAY 6-8 — National convention of the Society of Industrial Engineers in Cleveland, Ohio; headquarters, Hotel Winton. Executive secretary, George C. Dent, 608 S. Dearborn St., Chicago, Ill.

MAY 7-9—Ninth annual meeting of the American Gear Manufacturers' Association at the William Penn Hotel, Pittsburg, Pa. T. W. Owen, secretary, 2443 Prospect Ave., Cleveland, Ohio.

MAY 11-23 — (instead of January 19-31) Southern Exposition to be held at Grand Central Palace, New York City. Further information may be obtained from William G. Sirrine, Greenville, S. C., or the Merchants' Association of New York, 233 Broadway, New York.

MAY 18-21—Spring meeting of the American Society of Mechanical Engineers in Milwaukee, Wis. Secretary, Calvin W. Rice, 29 W. 39th St., New York City.

JUNE 16-19—Summer meeting of the Society of Automotive Engineers at Greenbrier Hotel, White Sulphur Springs, W. Va. Secretary, Coker F. Clarkson, 29 W. 39th St., New York City.

JUNE 22-26—Annual meeting of the American Society for Testing Materials at Chalfonte-Haddon Hall, Atlantic City, N. J. Secretary-Treasurer, C. L. Warwick, Engineers' Club Building, 1315 Spruce St., Philadelphia, Pa.

JUNE 24-26 — Twelfth National Foreign Trade Convention in Seattle, Wash. Secretary of the National Foreign Trade Council, O. K. Davis, India House, Hanover Square, New York City.

SEPTEMBER 8-11—Machine Tool Exhibition in the Mason Laboratory, Sheffield Scientific School, Yale University, New Haven, Conn. H. R. Westcott, chairman, 400 Temple St., New Haven, Conn.

NEW BOOKS AND PAMPHLETS

MANUAL FOR ENGINEERS. 244 pages, 2½ by 5½ inches. Published by the University of Tennessee, Knoxville, Tenn. Price, 75 cents.

This is the twenty-sixth edition of a vest-pocket manual for engineers, containing engineering tables and data, as well as general data of interest to the business man.

MECHANICAL WORLD YEAR BOOK FOR 1925. 348 pages, 4 by 6 inches. Published by Emmott & Co., Ltd., 65 King St., Manchester, England. Price, 1/6d.

This little pocket-book for mechanical engineers, which is now in the thirty-eighth year of its publication, is well known in the engineering field. It contains data and tables on steam engines, steam turbines, boilers, gas engines, oil engines, properties of metals and alloys, structural iron and steel work, gearing, grinding, gages, hydraulic work, machinery foundations, screw-cutting, and tables of squares, cubes and roots, logarithms, trigonometrical functions, and other engineering data.

STRUCTURAL ENGINEERS' HANDBOOK. By Milo S. Ketchum. 1065 pages, 6 by 9 inches. Published by the McGraw-Hill Book Co., Inc., 370 Seventh Ave., New York City. Price, $7.

This is the third edition of a handbook containing data for the design and construction of steel bridges and buildings. The book is written for the structural engineer and for the student or engineer who has had a thorough course in applied mechanics and the calculation of stresses in structures. The aim has been to provide a working manual for the engineer, draftsman, and student, covering data, details, and tables for the design of structures ordinarily met with. The new edition of this book has been revised and partially rewritten, and more than 130 pages of new material have been added. The tables in Part II have been revised to comply with the new standards adopted by the Association of American Steel Manufacturers.

MACHINE DESIGN. By S. J. Berard and E. O. Waters. 323 pages, 6 by 9 inches. Published by the D. Van Nostrand Co., 8 Warren St., New York City. Price, $2.50.

In the preparation of this book the aim has been to produce a work that would fill the gap between engineering drawing and advanced machine design, and serve as a guide both for students in technical schools and for young draftsmen preparing themselves to be designers. The plan is to give a logical and consistent development of approved methods of design applied to the more common elements of machine construction. An idea of the contents will be obtained from a list of the chapter headings: Elements of Theoretical Design; Conventional Practice; Fastenings; Shafting, Couplings, and Clutches; Bearings; Belting and Pulleys; Spur Gearing; Bevel Gearing; Worm Gearing; Screw Gearing; Cams; Linkages; Pistons and Stuffing-boxes; Piping, Fittings, and Rolled Shapes; and Drafting-room Systems.

NEW CATALOGUES AND CIRCULARS

TURRETS. McCrosky Tool Corporation, Meadville, Pa. Circular illustrating the use of McCrosky turrets for increasing the output of engine lathes.

CALENDAR. Moline Tool Co., Moline, Ill., is distributing to the trade a calendar for 1925, containing an illustrated poem entitled, "The End of the Road."

CONSTRUCTION ENGINEERING. Lockwood, Greene & Co., 1 Pershing Square, New York City. Calendar for 1925, illustrating typical industrial building erected by the concern.

PIPE THREADING MACHINES. Williams Tool Corporation, Erie, Pa. Circular entitled "A Family of Willing Workers," illustrating the different sizes and styles of Williams pipe threading machines.

CALENDAR. Associated British Machine Tool Makers, Ltd., 17 Grosvenor Gardens, London, S.W. 1, England. Calendar for 1925, illustrating the various machine tools built by the member companies.

FORGING INGOTS. Mesta Machine Co., Pittsburg, Pa. Booklet relating to the manufacture of Mesta forging ingots in fluted or special types and in sizes ranging from 17 to 56 inches in diameter.

PUNCHES AND DIES. Cleveland Punch & Shear Works Co., Cleveland, Ohio. Specification sheet of Cleveland punches and dies, giving standard sizes in stock, and diagrams for ordering special sizes.

CARBON DIOXIDE METERS. Brown Instrument Co., 4532 Wayne Ave., Philadelphia, Pa. Bulletin 32, entitled "Measuring CO_2 Electrically," describing principle of operation and the use of the CO_2 meter.

WRENCHES. Husky Wrench Co., 928 Sixteenth Ave., Milwaukee, Wis. Circular describing Husky interchangeable socket wrenches, which are so designed that with only six master units all types of wrenches are available.

ELECTRICAL RESISTORS. Monitor Controller Co., 500 E. Lombard St., Baltimore, Md. Bulletin 107, describing in detail the Monitor edgewound resistor, intended for use with motor starters and speed controllers.

MILLING MACHINES. Ingersoll Milling Machine Co., Rockford, Ill. Folder illustrating the special machines produced by this company in 1924. The folder also shows several machines developed particularly for railroad shops.

ELECTRIC EQUIPMENT FOR CRANES. General Electric Co., Schenectady, N. Y. Bulletin 48732, containing data on crane motors and control, brakes, etc. Information is also given on operating characteristics and types of standard motors.

HARDNESS TESTING MACHINES. Herman A. Holz, 17 Madison Ave., New York City. Bulletin 27, on hardness testing of metals and metal products, describing the Brinell method of hardness testing and the instruments used.

DRILLING MACHINES. Morris Machine Tool Co., Cincinnati, Ohio. Circulars containing illustrations and specifications covering the Morris 2- and 2½-foot and 3-foot high-speed radial drills, and the Morris 3- and 3½-foot heavy-duty radial drill.

GEARS. W. A. Jones Foundry & Machine Co., 4409 W. Roosevelt Road, Chicago, Ill. Catalogue 29, covering the complete line of spur, bevel, miter, worm, and spiral gears and speed-reducers made by this concern. Both dimensions and list prices are given.

DUST COLLECTORS. J. W. Paxson Co., Nicetown Lane and D St., Philadelphia, Pa. Folder illustrating and describing the Paxson cloth screen dust collector for removing fine powder and dust from the air. The material removed can also be salvaged by this device.

NICHROME CASTINGS. Driver-Harris Co., Harrison, N. J. Leaflet descriptive of the physical and chemical characteristics of nichrome castings. The leaflet is made to fit the Leflax loose-leaf binder used for the data book issued by the American Society for Steel Treating.

HOBBING MACHINES. Gould & Eberhardt, Chancellor Ave., Newark, N. J. Bulletin 140, describing the principles of design, construction, and operation of the new G & E No. 16 HS manufacturing hobbing machines, which are intended for the rapid production of accurate spur and helical gears.

BORING TOOLS AND REAMERS. Davis Boring Tool Co., Inc., St. Louis, Mo. Catalogue 24, covering the line of expansion boring and reaming tools made by this concern. The use of these tools in different classes of machines is illustrated, and complete data covering the different sizes are included.

SPROCKET WHEELS AND BELTING. W. A. Jones Foundry & Machine Co., 4409 W. Roosevelt Road, Chicago, Ill. Catalogue 32, descriptive of sprocket wheels and chain belting, as well as chain tighteners, elevator boots, buckets, bolts, handwheels, etc. Complete specifications, including prices, are given.

PISTONS. Aluminum Co. of America, Pittsburg, Pa. Reference book on aluminum pistons for the use of dealers, salesmen, garagemen, mechanics, and repairmen. The booklet deals with the function of gas engine pistons, advantages of aluminum pistons, piston troubles, piston design, types of pistons, points to be observed to insure successful operations, machining of aluminum pistons, etc.

BELTING. Leather Belting Exchange Foundation, 119 S. Fourth St., Philadelphia, Pa. Publication entitled "A Non-technical Summary of Research on the Applications of Leather Belting," by R. F. Jones, Research Director, covering a large number of experiments on pulley diameters, pulley ratios, center distances, effect of high belt speeds, the gravity idler, and new rating curves for leather belting.

ARC WELDING AND CUTTING APPARATUS. General Electric Co., Schenectady, N. Y., has published a 127-page volume, bound in cloth, called the "Arc Welding and Cutting Manual." The book is divided into three parts, the first of which is devoted to general information on arc welding, and the second to a training course for operators, while the third covers a number of applications of arc welding. It is being distributed at a nominal price.